50 MHz Portable Four Channel Oscilloscope

PM 3244

Instruction Manual/Gerätehandbuch/Notice d'emploi et d'entretien

9499 443 00702

791212/1/08

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810126 TEST AND MEASURING EQUIPMENT OSC 90

OSCILLOSCOPE PM 3244.

Already published:
- Cd 895, Cd 911, Cd 913
- OSC 20, OSC 33, OSC 34 and OSC 38 belonging to manual 9499 440 17002 for the PM 3244 up to version /08.
- Manual 9499 443 00702 for the PM 3244/08

Subject: Modifications to manual 9499 443 00702 for the PM 3244/08 and following versions.

Contents:

1 Z-unit (unit 11 - B 1301)
2 EHT converter (unit 6 - R 1408).
3 Final Y amplifier (unit 13 - TS 604, TS 608).
4 Earthing of the rear cabinet-plate.
5 Trigger source selector (unit 16 - R 714).
6 Removing the carrying handle.
7 Front cover box.
8 Mains filter.

9499 448 17211

1. Z-unit (unit 11).

The neon-tube B 1301 (ZA 1004) is changed to:
zenerdiode BZX 61 C 82 ordering number 5322 130 35005
This modification is introduced, because the neon-tube is no longer available.
When the neon-tube is ordered under ordering number 5322 131 90021, this tube will be delivered as long as it is available. After that the zenerdiode BZX 61 C 82 will be delivered.
If the neon-tube must be replaced by the zenerdiode, adapt and readjust the following:

– The zenerdiode must be mounted as indicated in fig. 1.

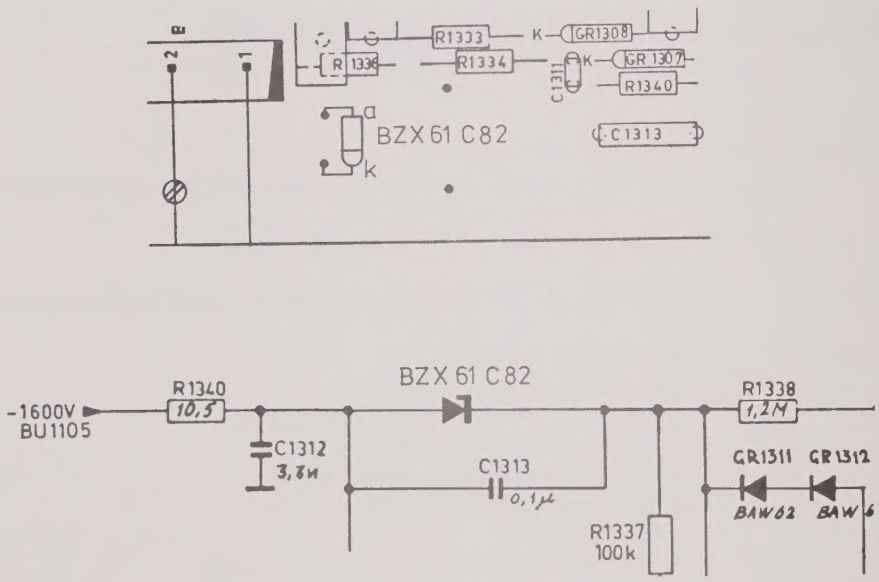

Fig. 1 Part of Z-unit (fig. 3.35 and 3.36 of the manual).

– To improve the Brilliance adjustment range of R 1327 the resistors R 1324 and R 1326 must be changed to:

R 1324 2k8	5322 116 55587
R 1326 2k67	5322 116 55616

– Readjust the intensity (R 1327) as described in section 3.7.4.2. of the manual.

2. EHT converter (unit 6)

To improve the performance of this unit resistor R 1408 is changed to 24 k9, ordering number 5322 116 54648

3. Final Y amplifier (unit 13)

The transistors TS 604 and TS 608 are changed to:

BFX 48 ordering number 5322 130 40208

This modification is introduced because the FW 5324 is no longer available.

4. Earthing of the rear cabinet plate.

The earthing of the rear cabinet plate is improved for safety purposes.
The rear cabinet plate must be mounted with two screws, **toothed-rings** and lock-washers on the cabinet.

5. Trigger source selector (unit 16).

To improve the adjustment range of R 705, resistor R 714 is changed to 1 k 1 ordering number 5322 116 54554

6. Removing the carrying handle.

When the carrying handle can not be removed as described in the PM 3244 manual, proceed as follows:

1. Remove the upper and lower cabinet plates.
2. Remove the plastic strip which is snapped on to the grip.
3. Remove the four screws which secure the grip to the brackets (these screws have been locked with a sealing varnisch).
4. Depress the push-buttons in the brackets and turn the carrying handle **as far as possible to the upper side** of the oscilloscope.
5. Keep the push-button of the right-hand bracket depressed and pull the bracket from its bearing [1)]
6. Remove the grip from the remaining bracket.
7. Depress the push-button of the left-hand bracket and turn the latter **as far as possible to the lower side** of the instrument.
8. Keep the push-button depressed and pull the bracket from its bearing.

If it is impossible to remove the left-hand bracket in this way, remove also its bearing in a similar way as described in footnote 1).

1) With some instruments it may be impossible to remove the handle in the described way. This is due to an extra securing plate in the right-hand bearing. In that case, **DO NOT USE FORCE,** but work in accordance with the following procedure which replaces points 3, 4 and 5.

   3. Remove the two screws which secure the grip to the right-hand bracket.
   4. Remove the two hexagonal bolts which secure the right-hand bearing to the side strip.
   5. Depress the push-button of the right-hand bracket and take the bearing from the bracket.

7. Front cover box.

The ordering number of the front cover box mentioned in the manual (page 123) belongs to the front cover of the PM 3240 and must be changed (for the PM 3244) to: 5322 447 94606.

8. Mains filter.

The mains filter unit (unit 3) given on page 156 of the manual is cancelled.
For the PM 3244 up to version 05, mains filter 5322 218 64045 must be used.
For the PM 3244/05 and following versions, mains filter FI 1801 ordering number 5322 121 44261 must be used.

50 MHz Portable Four Channel Oscilloscope

PM 3244

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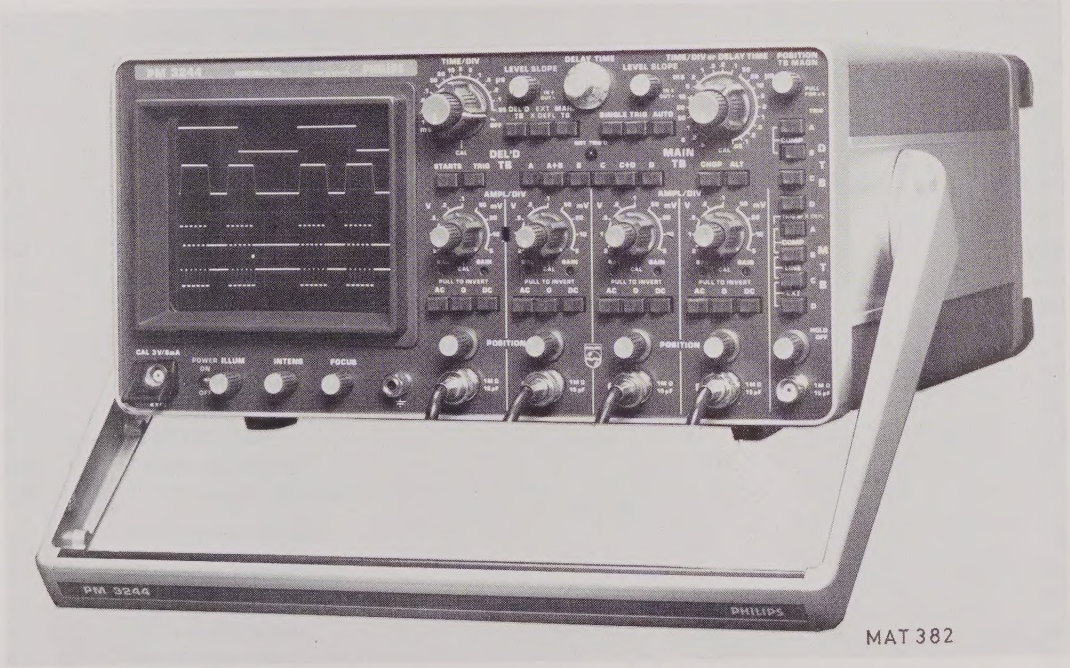
9499 443 00702

791212/1/08



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IMPORTANT

In correspondence concerning this instrument, please quote the type number and serial number as given on the type plate.

WICHTIG

Bei Schriftwechsel über dieses Gerät wird gebeten, die genaue Typenbezeichnung und die Gerätenummer anzugeben. Diese befinden sich auf dem Leistungsschild.

IMPORTANT

RECHANGE DES PIECES DETACHEES (Réparations)

Dans votre correspondance et dans vos réclamations se rapportant à cet appareil, veuillez TOUJOURS indiquer le numéro de type at le numéro de série sont marqués sur la plaquette de caractéristiques.

NOTE: *The design of this instrument is subject to continuous development and improvement. Consequently, this instrument may incorporate minor changes in detail from the information contained in this manual.*

BEMERKUNG: *Die Konstruktion und Schaltung dieses Geräts wird ständig weiterentwickelt und verbessert. Deswegen kann dieses Gerät von den in dieser Anleitung stehenden Angaben abweichen.*

REMARQUES: *Cet appareil est l'objet de développements et amélorations continuels. En conséquence, certains détails mineurs peuvent différer des informations données dans la présente notice d'emploi et d'entretien.*

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Operating manual

1.General information

1.1. Introduction

The PM 3244 portable h.f. oscilloscope features four identical vertical deflection channels with high sensitivity (5 mV/div.) over a large bandwidth of 50 MHz.

There is a wide choice of vertical deflection possibilities, such as one, two, three or four channels (alternately or chopped) Also adding of the first two channels and of the last two channels is possible.
The polarity of each channel can be inverted.

Horizontal deflection possibilities are: main time base (with or without intensified delay time base), delayed time base, or external deflection.

Except the normal trigger source choice the PM 3244 also features composite triggering.

This oscilloscope has a low dissipation tapless power supply, working on any a.c. line voltage between 90 V and 270 V, or any d.c. voltage between 100 V and 350 V.

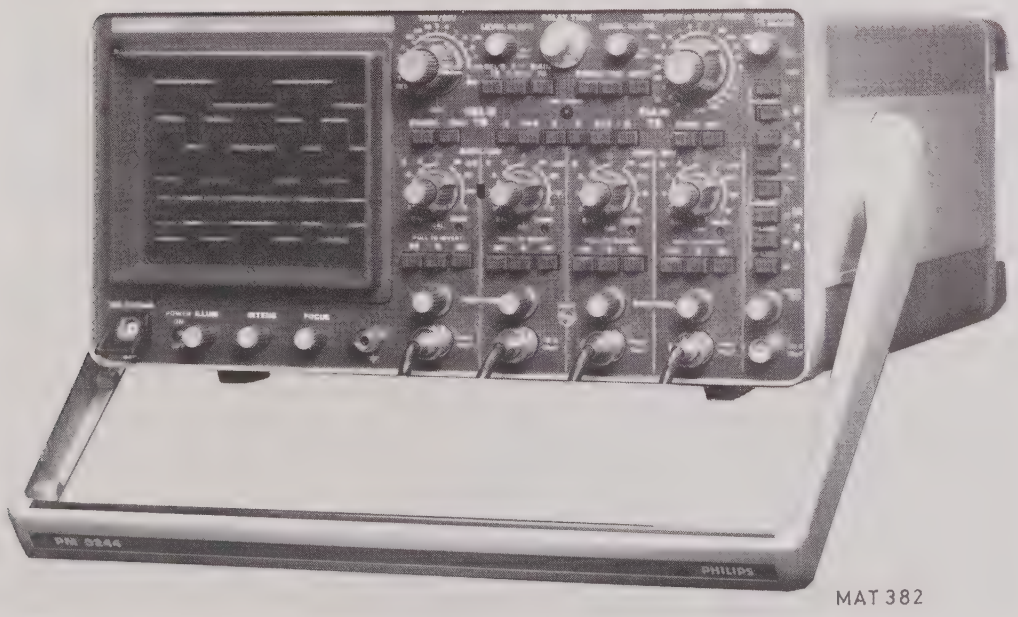

Fig. 1.1. Portable four channel H.F. oscilloscope PM 3244

1.2. CHARACTERISTICS

This specification is valid after the instrument has warmed up for 30 minutes.
Properties expressed in numerical values with tolerances stated, are guaranteed by the manufacturer.
Numerical values without tolerances are typical and represent the characteristics of an average instrument.

This instrument has been designed and tested in accordance with IEC Publication 348 for Class I instruments and has been supplied in a safe condition. The present Instruction Manual contains information and warnings which shall be followed by the purchaser to ensure safe operation and to retain the instrument in a safe condition.

	Designation	*Specification*	*Additional Information*
1.2.1.	**C.R.T.**		
	Type	D14-125 GH/37	Rectangular tube face, mesh type, post accelerator, metal backed phosphor.
	Measuring area	80 mm x 100 mm	Divided in 8x10 divisions.
	Screen phosphor	P31 (GH)	P11 (BE) and P7 (GM) phosphor optional.
	Photographic writing speed	750 cm/μs	Measured with Steinheil Oscillophot M5 camera Aperture 1:1,2 Object to image ratio 1:0,5 Film: Polaroid 410 (10000 ASA) No pre-fogging Phosphor P31 (GH)
	Total acceleration voltage	10 kV	
	Graticule	8x10 cm divisions with sub-divisions of 2 mm along the central axes.	Dotted lines indicate 10 % and 90 % of measuring lattice for rise-time measurements.
	Graticule illumination	Continuous variable	Maximum brightness clearly visible under normal lab. type light conditions.
1.2.2.	**Vertical deflection (Y)**		
	Number of channels	4	Four identical channels, marked A, B, C en D
	Display modes	Channel A only Channel B only Channel C only Channel D only Channels A+B added Channels C+D added either of these modes in any combination, chopped or alternatively displayed. All channels can be inverted.	
	Display time per channel in chopped mode	Approx. 0.5 μs	From /03 version: switchable between 0.5 μs and 2 μs (see Fig. 3.47)
	Frequency range	d.c. ... 50 MHz 10 Hz ... 50 MHz	d.c. coupled Upper bandwidth limit –3 dB a.c. coupled –3 dB bandwidth limit
	Rise time	$\approx$ 7 ns	
	Aberrations	$\pm$ 2 % max.	Measured with test pulse of 6 div. deflection / 1 ns rise time and 1 μs repetition time.

Designation	*Specification*	*Additional Information*
Deflection coefficients	5 mV/DIV ... 2 V/DIV	Nine calibrated positions in 1-2-5 sequence. Uncalibrated, continuous control 1 : ⩾ 2,5.
Accuracy	± 3 %	
Input voltage	± 400 V max.	d.c. + a.c. peak In the 5 mV/DIV ... 20 mV/DIV positions of the input attenuator derating at frequencies over 500 kHz. Refer to Fig. 1.2.
Max. deflection	24 div. ⩾ 6 div.	For sine waves up to 15 MHz. For sine waves from 15 MHz up to 50 MHz.
Max. total signal amplitude in A-B and C-D modes	24 x attenuator-setting	Attenuators in CAL. positions.
Positioning range	16 div.	
Common-mode rejection	⩾ 100:1 at 1 MHz	After adjusting
Cross talk between channels	35 dB max.	For all attenuator combinations. Reference is 6 div. signal amplitude (0 ... 50 MHz) Chopped mode.
Tracé stability D.C. drift	⩽ 0,3 div/h at 20 °C	After 15 min. warm-up
Temp. drift	⩽ 60 μV/°C typical	
Attenuator balance	⩽ 0,3 div.	When switching between any of the attenuator positions.
Input		
Impedance	1 Mohm//15 pF	
Coupling	AC-0-DC	
RC time	22 ms	Coupling switch in AC position.
Visible signal delay	20 ns	

1.2.3. Horizontal deflection (X)

Display modes	– Main time base – Main time base intensified by delayed time base – Delayed time base – X/Y mode	Up to four trace X/Y operation with X deflection by one of the four vertical channels, or an external signal, or the line signal.

Horizontal deflection amplifier

Bandwidth	d.c. ... 1 MHz	over 6 div's – 3 dB upper bandwidth limit
Deflection coefficient	450 mV/div Vertical attenuator coefficients	using EXT input apply when one of the vertical channels is used for horizontal deflection
Accuracy	± 10 %	Using one of the vertical channels for horizontal deflection.
Input impedance	1 Mohm//15 pF	
Phase difference between Vert. and Hor. defl. amplifier	less than 3°	at 100 kHz

	Designation	*Specification*	*Additional Information*
	Deflection by line voltage	8 div's	The deflection depends on the line voltage and has been factory-adjusted to 8 DIV at a line voltage of 220 V.
1.2.4.	**Main time base**		
	Operation	Automatic Triggered Single shot	In the AUTO mode the time base is free-running approx. 100 ms. after disappearance of the trigger signal.
	Time coefficients	0,5 s/DIV ... 50 ns/DIV.	Twenty-two calibrated positions in 1-2-5 sequence. Uncalibrated, continuous control 1 : ⩾ 2,5
	Accuracy	± 3 %	± 5 % for 0.5 s/DIV and 0.2 s/DIV ± 5 % for 100 ns/DIV and 50 ms/DIV
1.2.5.	**Delayed time base**	Direct running after delay time or triggerable after delay time	
	Time coefficients	1 ms./DIV ... 50 ns./DIV	Fourteen calibrated positions in 1-2-5 sequence. Uncalibrated, continuous control 1 : ⩾ 2,5
	Accuracy	± 3 %	± 5 % for 100 ns./DIV and 50 ns./DIV
	Time Base Magnifier		
	Magnification	x5	
	Highest effective sweep speed	10 ns./div.	
	Additional tolerance	± 2 %	
1.2.6.	**Triggering of M.T.B.**		
	Source	Internal Composite Line External	From ch. A, B, C or D
	Trigger bandwidth	d.c. ... 50 MHz	Upper bandwidth limit −15 dB
	Trigger sensitivity	Internal ⩽ 0,5 div. External ⩽ 250 mV	0,3 div. typical 150 mV typical
	Slope selection	+ or −	
	Ext. trigger input impedance	1 Mohm//15 pF	Identical to any vertical deflection input
	Input voltage	± 400 V max.	d.c. + a.c. peak
1.2.7.	**Triggering of D.T.B.**		
	Identical to main time base triggering except:		
	Source	Internal Composite	From ch. A, B, C or D
	Sweep delay		
	Delay time	Continuously variable between 0.3x and ⩾ 10x the time-coefficient of the main time base.	Adjustable with calibrated ten turn dial knob.
	Incremental delay time error	0,5 %	
	Delay time jitter	⩽ 1 : 20 000	

	Designation	*Specification*	*Additional Information*
1.2.8.	**Calibration unit**		
	Voltage	3 V_{p-p}	Square wave, base-line zero volts
	Current	6 mA	Through current loop
	Accuracy	± 1 %	For both voltage and current
	Frequency	2 kHz ± 2 %	
	Protection	The output is short-circuit-proof	
1.2.9.	**Power supply**		
	Line voltages	90 ... 270 V AC or 100 ... 350 V DC	In one range
	Line frequency	46 ... 440 Hz or DC	
	Build-in line fuse	1,6 amp. delayed-action	For all line voltages
	Power consumption	29 W	

1.2.10. **Environmental characteristics**

The environmental data are valid only if the instrument is checked in accordance with the official checking procedure. Details on these procedures and failure criteria are supplied on request by the PHILIPS organisation in your country, or by N.V. PHILIPS' GLOEILAMPENFABRIEKEN, TEST AND MEASURING DEPARTMENT, EINDHOVEN, HOLLAND.

Ambient temperature	+5 °C ... +40 °C −10 °C ... +55 °C −40 °C ... +70 °C	Rated range of use Limit range of operation Storage and transport
Altitude	5000 m (15000') 15000 m (45000')	Operating Non operating
Humidity	The instrument meets the requirements of the IEC 68 Db recommendations.	
Bump	1000 bumps of 10 g, ½ sine, 6 ms duration, in each of 3 directions	I EC 68 E b
Vibration	30 minutes in each of three directions, 10-150 Hz; 0,7 mm p-p and 5 g max. acceleration	I EC 68 F
Recovery time	30 minutes for normal operation	Coming from −10 °C and going to +20 °C at 60 % relative humidity.
Electromagnetic interference	The instrument meets the VDE, Störgrad K, requirements.	

1.2.11. **Mechanical data**

Dimensions	Length 410 mm (16 1/4") Width 316 mm (12 1/4") Height 154 mm (6 1/8")	Excl. controls, cover and feet
Weight	9,7 kg	

1.2.12. **Delivered accessories**

Contrast filter
Front cover
Collapsible viewing hood PM 9366
BNC-banana adaptor PM 9051
Cal. terminal to BNC adaptor
Operating and service manual

1.2.13. Optional accessories

PM 9335	Passive probe set 1 : 1 (1.5 m)
PM 9335L	Passive probe set 1 : 1 (2.5 m)
PM 9350	Passive probe set 10 : 1 11 pF (1.5 m)
PM 9350L	Passive probe set 10 : 1 14 pF (2.5 m)
PM 8927	Passive probe set 10 : 1 (1.5 m)
PM 8927L	Passive probe set 10 : 1 (2.5 m)
PM 9358	Passive probe set 100 : 1; max. voltage 5600 V; 2 pF (1.5 m)
PM 9347	Active TV triggering probe 10 : 1 11 pF (1.5 m)
PM 9352	Micro miniature probe 10 : 1 6 pF (2.5 m)
PM 9353	Active FET probe 1 : 1; 10 : 1; 100 : 1, 3.5 pF (1.5 m)
PM 9355	Current probe; 1 mA/div. ... 1 A/div.; 12 Hz ... 70 MHz
PM 9346	Power supply for active probes
PM 8960	19 inch rack mount adaptor
PM 8992	Accessory pouch
PM 9380	Oscilloscope camera
PM 8971	Adapter for oscilloscope camera
PM 8910	Polaroid anti-glare filter
PM 8980	Long type viewing hood
PM 8901	Battery pack 24 V dc and 330 V dc
PM 8991	Oscilloscope trolley

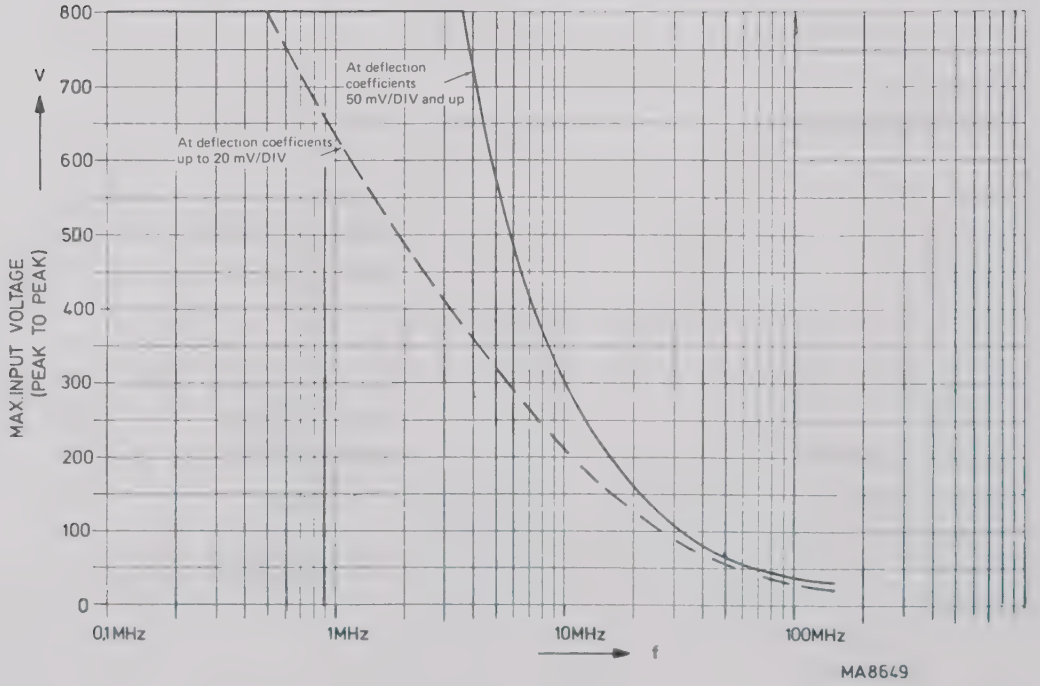

Fig. 1.2. Derating of the maximum permissible input voltage as a function of frequency

Fig. 2.1. Removing the front cover.

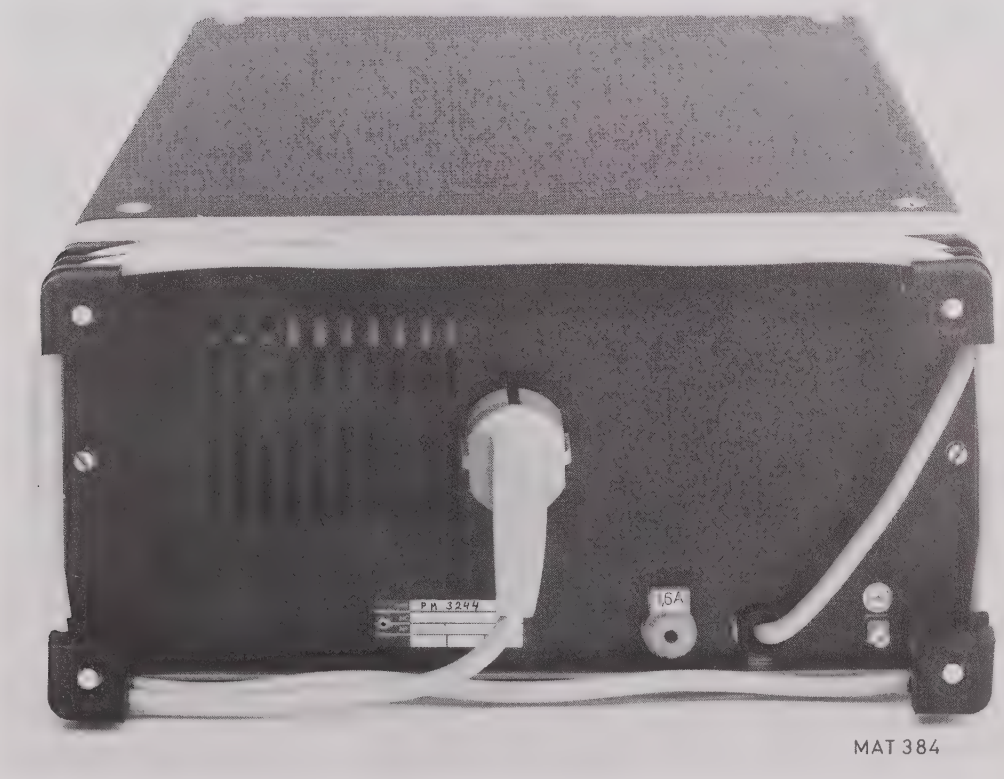

Fig. 2.2. Rear view of the instrument.

2. Directions for use

2.1. INSTALLATION

2.1.1. Removing and fitting the front cover (see fig. 2.1.)

Removing:
- Turn the knob in the centre of the cover a quarter of a turn anti-clockwise to the UNLOCKED position.
- Take the cover off.

Fitting:
- Align the key of the locking knob with the slot in the text plate of the instrument.
- Fit the cover over the front of the oscilloscope.
- Press the knob and turn it a quarter of a turn clockwise to the LOCKED position.

Remark: The handle can be rotated if the push-buttons on its bearings are depressed.

WARNING: This instrument generates high voltages and should not be operated with the cabinet plates removed. The line plug must be removed before attempting any maintenance work, and any relevant high-voltage points discharged.
Before any other connection is made, the protective earth terminal shall be connected to a protective conductor (see section *earthing*).

2.1.2. Mains adaption and fuse

The ability of the instrument to operate at any mains voltage between 90 and 270 V a.c. or between 100 and 350 V d.c. obviates the need of adaption to the local mains voltage.
The fuse holder is mounted on the rear panel. The 1,6 A delayed action fuse is used at all mains voltages.
Make sure that only fuses with the required rated current and of the specified type are used for replacement.
The use of mended fuses and the short-circuiting of fuse holders shall be avoided. The instrument shall be disconnected from all voltage sources when a fuse is to be replaced.

2.1.3. Earthing

Before switching on, the instrument shall be connected to a protective earth conductor in one of the following ways:
- Via the protective earth terminal (identified by the symbol ⏚).
- Via the three-core line cable. The line plug shall only be inserted into a socket outlet provided with a protective earth contact. The protective action shall not be negated by the use of an extension cord without protective conductor.

WARNING: Any interruption of the protective conductor inside or outside the instrument, or disconnection of the protective earth terminal, is likely to make the instrument dangerous. Intentional interruption is prohibited.

When an instrument is brought from a cold into a warm environment, condensation may cause a hazardous condition. Therefore, make sure that the earthing requirements are strictly adhered to.

2.1.4. Dismantling

The opening of covers or removal of parts, except those to which access can be gained by hand, is likely to expose live parts and also accessible terminals may be live.

The instrument shall be disconnected from all voltage sources before any adjustment, replacement or maintenance and repair during which the instrument will be opened.

If afterwards any adjustment, maintenance or repair of the opened instrument under voltage is inevitable, it shall be carried out only by a skilled person who is aware of the danger involved.

Replacing the mains plug is at the user's own risk. After replacing a mains plug, a high-voltage test in accordance with IEC Publication 348 is strongly recommended.

Bear in mind that capacitors inside the instrument may still be charged, even if the instrument has been separated from all voltage sources.

2.1.5. Switching on

The POWER switch is incorporated in the graticule ILLUMination control on the front panel, immediately below the screen bezel. The oscilloscope must never be switched on whilst any circuit board has been removed. Never remove a circuit board until at least one minute after the oscilloscope has been switched off.

2.2. FUNCTION OF CONTROLS AND INPUT SOCKETS

2.2.1. Vertical deflection

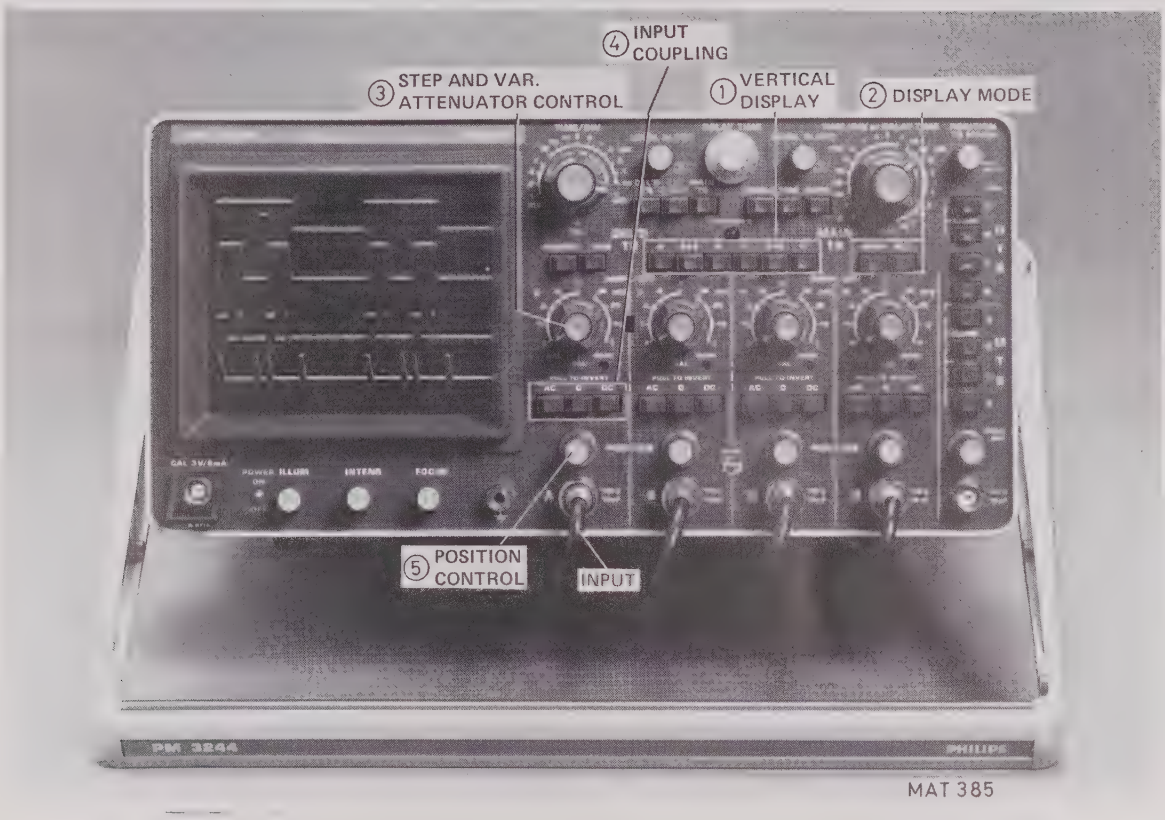

Fig. 2.3. Vertical deflection

1. Vertical deflection mode switch.

Button A	channel A
Button A+B	channels A and B algebraically added
Button B	channel B
Button C	channel C
Button C+D	channels C and D algebraically added
Button D	channel D

Any combination of above displays is possible (if no button depressed, channel A is on).

2. CHOP-ALT switch

The under point 1 mentioned channel displays, can be in the chopped- or the alternated mode, depending of this switch (if no button depressed and two or more channels are on, the display is in the chopped mode).

3. Attenuator controls

AMPL/DIV	Step control of the deflection coefficients combined with:
AMPL/CAL	Continuously variable control of the deflection coefficients. If this knob is pulled-out the channel polarity is inverted.

4. Input coupling switch

AC	Signal coupling via a blocking capacitor.
0	Channel input connected to earth; signal-load open.
DC	Direct coupling.

(If no button is depressed, the AC situation is on).

5. POSITION — Continuously variable control giving vertical shift of the relevant channel.

PRE-SET CONTROLS:

BAL	Step attenuator balance
GAIN	Step attenuator amplitude calibration.

2.2.2. Horizontal deflection (x)

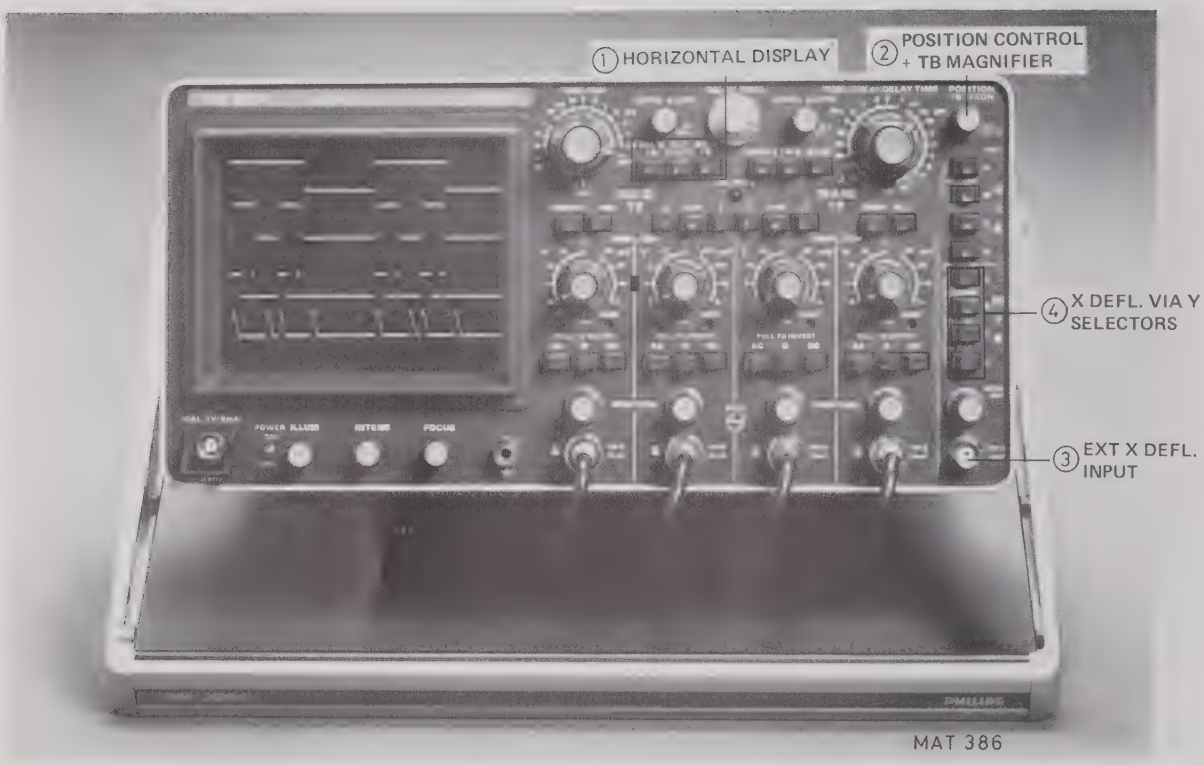

Fig. 2.4. Horizontal deflection.

1. Horizontal deflection mode switch.

MAIN TB	The horizontal deflection is provided by the main time base generator. A part of the display is intensified when the delayed time base is on.
EXT X DEFL	Horizontal deflection is achieved by an external signal coming from: – Input socket of the horizontal amplifier (3) – One of the vertical deflection channels (4) – The line (4).
DEL'D TB	The horizontal deflection is provided by the delayed time base generator (if no button is depressed, the main tb is on).

2. Position and TB magnifier

POSITION	Continuously variable control giving horizontal shift of the display.
TB MAGN	Push-pull switch which increases the time-base coefficients by a factor of 5. Not operative in the EXT X DEFL. mode.

2.2.3. Main time base

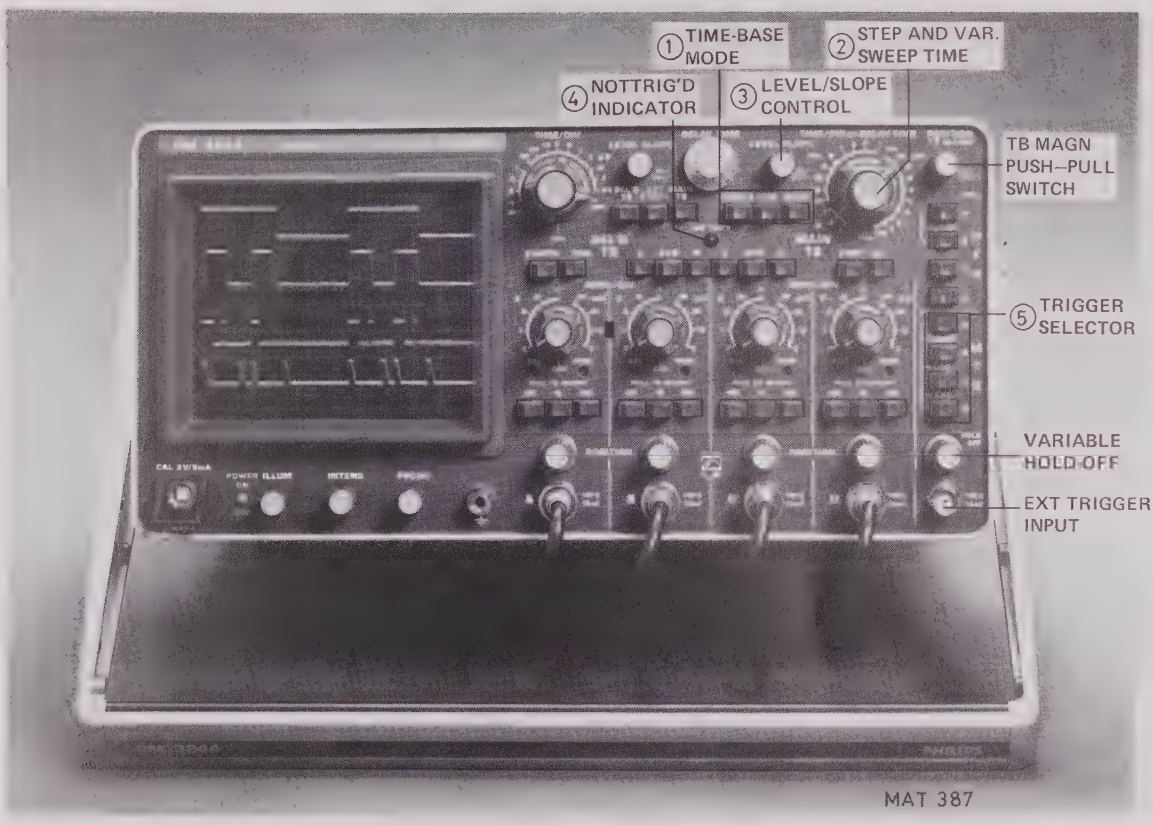

Fig. 2.5. Main time base

1. Main time-base mode switch

AUTO	The main time-base generator is free-running when no trigger pulses are present.
TRIG	The main time-base is normally triggered.
SINGLE	Single sweep time-base. After operating the SINGLE button, the main time-base generator runs only once upon receipt of a trigger pulse. (If no button is depressed the time-base is in the single sweep mode.)

2. TIME/DIV or DELAY switch — Step control of the main time-base time coefficients: 22-way rotary switch. If the delayed time-base is operating, the delay time after which the delayed time-base starts, is the product of the DELAY TIME calibrated dial setting and the TIME/DIV coefficient of this switch.

TIME/DIV CAL	Continuously variable control of the time coefficients.

3. LEVEL/SLOPE — Continuously variable control to select the trigger level at which the time-base generator starts.
The push-pull switch enables choice of triggering on the positive- or negative-going slope of the singal.

4. NOT TRIG'D indicator — Lights up when the main time-base generator is not triggered.

5. MTB Trigger source selector switch — This switch consists of four buttons (A, B, C and D) to select the trigger signal from one of the vertical deflection channels.
When both buttons A and B are depressed, the composite trigger signal is selected.
When both buttons B and C are depressed, part of the line voltage is used as a trigger signal.
When both buttons C and D are depressed, the signal applied to the EXT connector is used as a trigger signal.
(If no button is depressed, the A trigger signal is on.)

2.2.4. Delayed time base

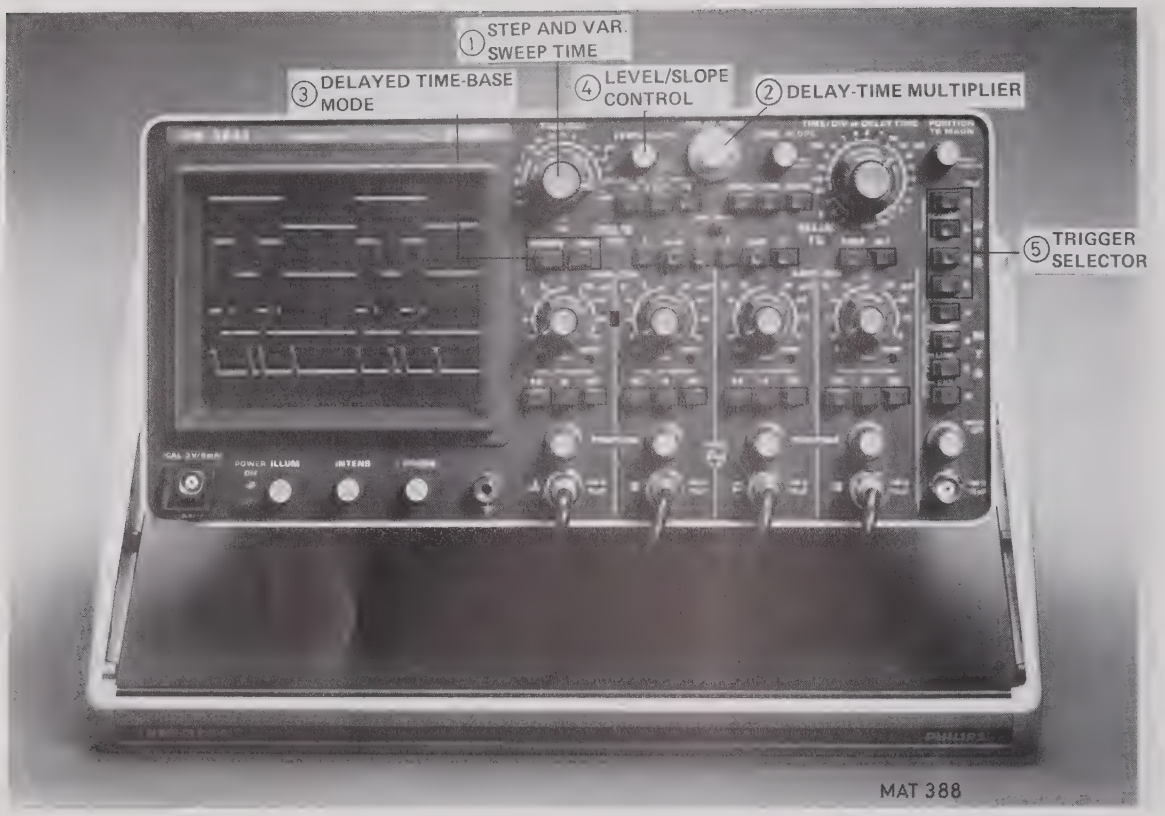

Fig. 2.6. Delayed time base.

1. TIME/DIV switch	Step control of the delayed time-base time coefficients; 14-way rotary switch. In the OFF position the delayed time-base is not operating.
TIME/DIV CAL	Continuously variable control of the time-base coefficients.
2. DELAY TIME	Calibrated ten-turn dial knob to adjust the delay time after which the delayed time base becomes operative. This delay time is the product of the DELAY TIME dial setting and the TIME/DIV coefficient switch of the main time-base.
3. STARTS/TRIG	If the STARTS button has been depressed, the delayed time-base starts immediately after the delay-time (the delayed time-base requires then no trigger signal). If the TRIG. button has been depressed the delayed time-base starts after the delay-time upon receipt of a trigger pulse. (No button depressed has the same effect as the STARTS button depressed.)
4. LEVEL/SLOPE	Continuously variable control to select the trigger level at which the delayed time-base generator triggers. The push-pull switch enables choice of triggering on the positive- or negative-going slope of the signal.
5. DTB Trigger source selector switch	This switch consists of four buttons (A, B, C and D) to select the trigger signal from one of the vertical deflection channels. When both buttons A and B are depressed, the composite trigger signal is selected. (If no button depressed, the A trigger signal is on).

2.2.5. C.R.T. display section

1. POWER/ILLUM	Continuously variable control of the graticule illumination combined with power on-off switch. Pilot lamp indicates the ON state.
2. INTENS	Continuously variable control of the display-brightness.
3. FOCUS	Continuously variable control of the electron-beam focussing.

Miscellaneous

1. CAL	Output socket for calibration of: – The gain of the vertical deflection amplifier and, – The frequency compensation of attenuator probes. Suited for voltage probes and current probes.

2.3. PRELIMINARY SETTINGS

Before measurements with this oscilloscope are carried out, check that the step-attenuator balance and the gain calibration for all channels are well adjusted.
If necessary proceed as follows:

1. Adjusting the step attenuator d.c. balance
   - Depress the MAIN TB button of the horizontal deflection mode switch.
   - Depress the AUTO button of the main time-base mode switch.
   - Set the INTENSITY and FOCUS controls for a sharp, well-defined trace.
   - Depress the relevant channel button of the vertical deflection mode switch.
   - Depress the 0 button of the input coupling switch.
   - Set the POSITION knob so that the trace is somewhere about in the centre of the screen.
   - Set the AMPL continuous control to position CAL.
   - Check that the trace does not jump when the AMPL switch knob is rotated.
     If necessary, adjust the BAL control.
   - Repeat for each channel.
2. Gain calibrations
   Unless otherwise stated, the controls occupy the same positions as in the previous procedure.
   - Set the AC-0-DC switch to AC.
   - Set the AMPL switch knob to .5 V and the continuous control to CAL.
   - Connect the channel input to the CAL output.
   - Check the vertical deflection is exactly 6 divisions.
     If necessary adjust the GAIN control.
   - Also an attenuator probe can be included in this calibration. The probe attenuation factor must then be taken into account with respect to the AMPL switch position.
   - Repeat for each channel.

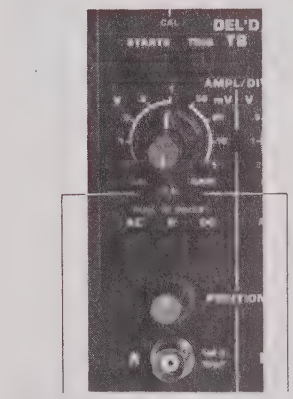

Fig. 2.7.

2.4. OPERATING INSTRUCTIONS

2.4.1. General

Before switching-on, ensure that the oscilloscope has been correctly installed in accordance to the INSTALLATION RECOMMENDATIONS (Chapter 2.1.) and the precautions outlined have been observed.

2.4.2. Vertical deflection

To display the desired channels depress the corresponding buttons of the vertical deflection mode switch. If two or more traces are displayed, the display can be in the alternate- or the chopped mode.
In the alterate mode the channels are displayed successively; during fly-back of the main time-base sweep the display is switched-over from one channel to another.
In the chopped mode the channels are switched-over from one to another during the time-base sweep. The display time in the chopped mode is approx. 500 ns per channel. From /03 version switchable between 0.5 and 2 μs, see fig. 3.4 7.
To obtain a steady display generally the alternate mode is used at the higher sweep speeds and the chopped mode at the lower sweep speeds.

Note that in the composite trigger mode, the alternate display mode must be chosen, otherwise the chopper pulses will influence the trigger circuit.
The signals under observation are fed to input socket(s) A ... D and the AC/0/DC switch is set to either AC or DC, depending upon the composition of the signal. As the vertical amplifiers are d.c. coupled, the full bandwidth of the instrument is available and d.c. components are displayed as trace shift in the DC position of the AC/0/DC switch.
This may be inconvenient when small signals superimposed on high d.c. voltages must be displayed. Any attenuation of the signal will also result in attenuation of the small a.c. component. The remedy is to use the AC position of the input switch, which employs a blocking capacitor, to suppress the d.c. component. Some pulse droop, however, will occur when l.f. square-wave signals are displayed.

The 0 position interrupts the signal-path and earths the amplifier-input for quickly determining the 0 V level. With the position controls the display can be shifted in vertical direction. Note that in the composite trigger mode the trigger start point also is influenced by the vertical position control.

2.4.3. Horizontal deflection

Depending on the position of the horizontal display switch the horizontal deflection can be:
- Main time-base
- Ext. X defl.
- Delayed time-base.

With the position control, combined with time-base magnifier, the display can be shifted in horizontal direction.

If the MAIN TB or DEL'D TB button is depressed, the horizontal deflection is effected by the main time-base or the delayed time-base respectively. If the EXT X DEFL button is depressed the horizontal deflection can be taken from:
- One of the vertical deflection channels A, B, C or D
- Line voltage (mains)
- Externally via EXT connector

2.4.4. Main time base

Linear horizontal deflection is obtained when the MAIN TB button of the horizontal display switch is depressed.
The time-base mode can be chosen with the time-base mode switch:

AUTO — Time-base is running, also if no trigger pulses are present.
The trace is, therefore, always visible.
The AUTO mode can be used in all cases where also the TRIG mode is usable, except with signal frequencies lower than 10 Hz, or pulse trains with an off-time exceeding 100 ms. As soon as trigger pulses are present, the free-running state of the time-base is automatically terminated and the time-base generator is normally triggered.

TRIG — The time-base is visible when trigger pulses are present and trigger-level control is correct.

SINGLE — The time-base makes only one sweep after receipt of a trigger pulse. After this sweep the time-base must be reset by depressing the SINGLE button once again.
When effects which occur only once, have to be observed (usually photographed), it is often desirable to ensure that only one sweep is generated, even though several trigger pulses might be produced after the phenomenon of interest.

2.4.5. Triggering

If one or more signals must be displayed, the time-base sweep must always be started on one fixed point of the signal, in order to obtain a stationary display.
The time-base generator is, therefore, started by trigger pulses which are derived from the following signal sources, depending on the main time-base trigger selector switch:
- One of the vertical deflection channels A, B, C or D
- Composite signal
- Line voltage
- External voltage

The amplitudes of the trigger signals from one of the vertical deflection channels, or from the composite signal are proportional to the vertical deflection of the display, hence depending on the input attenuator settings.

For composite triggering buttons A and B must be depressed, in this mode the trigger signal is taken from the common vertical deflection amplifier. Composite signal triggering features:

a. Triggering by differential signals if e.g. the instrument is in the A+B mode, with one of the input voltages inversed.
b. Two up to four signals with different, non-related frequencies can be displayed.
   In this case the trigger points of the various signals must be in the same trigger level range.

Note: — When triggering in the composite mode, the display must always be in the ALT mode.
In the CHOP mode the chopper pulses will function as trigger pulses hence the display will be unstable.
— In the composite triggering mode the trigger point of the signal depends also on the vertical POSITION control. A small modification for "AC" composite triggering described in part 3.2.2. solves this problem.

Line triggering is realised by depressing both buttons B and C.
The main time-base is triggered by part of the line voltage (mains). The coupling with the line voltage is obtained by a build-in opto-isolator circuit, hence the instrument remains isolated from the line voltage.

External triggering is realized by depressing both buttons C and D.
The main time-base is now triggered by an external signal applied via the EXT connector.

With the LEVEL control the point of triggering on the slope of the signal can be chosen.
The SLOPE push-pull switch permits selection of the positive- or negative going slope.

If the main time-base generator gets no trigger pulses the NOT TRIG'D indicator lights up.
In the SINGLE sweep mode this indicator lights up if the time-base generator has been reset and is waiting for the next trigger pulse.

The sweep time of the main time-base is set with the knob TIME/DIV or DELAY TIME. If the delayed time base is switched on, the time between starting of the main time-base and delayed time-base-sweep, is the product of the settings of the DELAY TIME 10-turn knob and the main time-base sweep time switch. With the centre knob time-base sweep times between the steps can be adjusted. For time-measurements this knob must always be in the CAL position.
The TIME/DIV coefficient of the time-base can be increased by a factor of 5, by pulling the TB MAGN push-pull knob.

With the HOLD OFF control, the hold-off time of the main time-base generator can be varied. This is the time the time-base generator needs to be ready for receipt of the next trigger pulse. The HOLD OFF control permits steady display of more complicated signals e.g. periodic double-pulses.
Fully clockwise is the normal position of the HOLD OFF control. Turning anti-clockwise the hold-off time is extended.

2.4.6. Delayed time base

If the MAIN TB button of the horizontal display switches is depressed, and the delayed time-base TIME/DIV knob is not in the OFF position, part of the main time-base sweep line is displayed at higher intensity.
The moment the delayed time-base is starting is determined by the settings of the main time-base TIME/DIV knob and the DELAY TIME 10-turn knob. If the STARTS button of the delayed time-base mode switch is depressed, the delayed time-base starts immediately after this delay time.
If the TRIG button is depressed the delayed time-base will start after this delay time and upon receipt of a trigger pulse.

The delayed time-base trigger selector has the same possibilities as the main time-base trigger selector except line and ext. triggering.
The LEVEL/SLOPE control function is the same as described for the main time-base.
The sweep time of the intensified part of the main time-base sweep depends on the setting of the delayed time-base TIME/DIV knob.
With the centre knob sweep times between the steps can be adjusted. For time measurements this knob must always be in the CAL position.

If the DEL'D TB button of the horizontal mode switch is depressed the intensified part of the main time-base sweep is displayed over the whole screen.

Gebrauchsanleitung

1. Allgemeines

1.1. EINLEITUNG

Der tragbare H.F. Oszillograf PM 3244 verfügt über vier identische Vertikalablenkungskanäle mit höchster Empfindlichkeit (5 mV/Teil) über eine grosse Bandbreite von 50 MHz.

Das Gerät bietet vielseitige Vertikalablenkmöglichkeiten, wie ein, zwei, drei und vier Kanäle (alternierend oder gechopped). Es gestattet auch Addition der ersten zwei und der letzten zwei Kanäle.
Die Polarität jedes Kanals kann invertiert werden.

Horizontalablenkmöglichkeiten sind: Hauptzeitbasisablenkung (mit oder ohne aufgehellter verzögerter Zeitbasis), verzögerte Zeitbasisablenkung oder externe Ablenkung.

Ausser der normalen Triggerquelle-Einstellung ermöglicht der PM 3244 auch zusammengesetzte Triggerung.

Der PM 3244 hat eine Speisung mit niedriger Verlustleistung die bei jeder beliebigen Wechselspannung zwischen 90 V und 270 V und bei jeder beliebigen Gleichspannung zwischen 100 V und 350 V betriebsfähig ist.

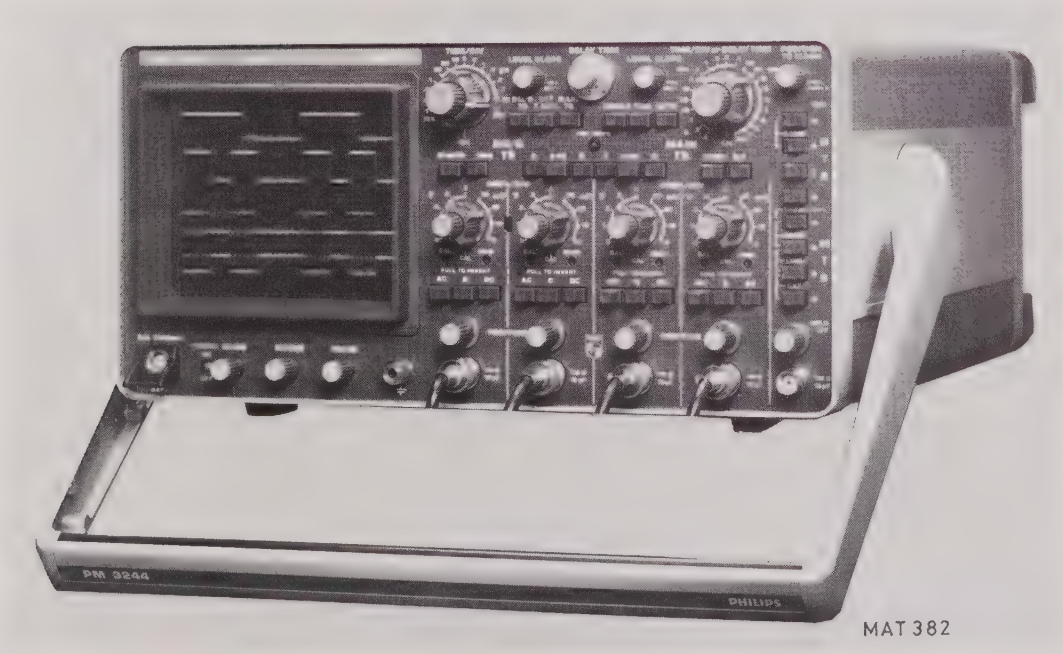

Abb. 1.1. Tragbarer Vierstrahl Hochfrequenz-Oszillograf PM 3244

1.2. TECHNISCHE DATEN

Dieses Gerät ist gemäss IEC 348, Sicherheitsbestimmungen für elektrische Mess- und Regeleinrichtungen, gebaut und geprüft und hat das Werk in sicherheitstechnisch einwandfreiem Zustand verlassen. Um diesen Zustand zu erhalten und einen gefahrlosen Betrieb sicherzustellen, muss der Anwender die Hinweise und Warnvermerke beachten, die in dem vorliegenden Gerätehandbuch enthalten sind.

Nur Angaben mit Toleranzen oder Grenzwerten können als garantierte Daten angesehen werden. Daten ohne Toleranzen, d.h. ohne Fehlergrenzen, sind informative Daten und werden nicht garantiert.
Fehlerangaben gelten nach einer Anwärmzeit von 30 Minuten nach dem Einschalten.
Prozentuale und absolute Fehler sind auf den jeweils angegebenen Referenzwert bezogen.

Benennung	*Beschreibung*	*Nähere Angaben*
1.2.1. Elektronenstrahlröhre		
Typ	PHILIPS D14-125 GH/37	Rechteckiger Schirm, mit Netzelektrode und Nachbeschleuniging, metallhinterlegter Leuchtschirm.
Ausnutzbare Schirmfläche	80 mm x 100 mm	
Schirmtyp	P31 (GH) Phosphor	P11 (BE) und P7 (GM) Phosphor auf Wunsch lieferbar.
Photografische Schreibgeschwindigkeit	750 cm/µs	Gemessen mit Steinheil Oscillophot M5 Kamera. Blende: 1:1,2 Bildausschnitt Verhältnis: 1:0,5 Film: Polaroid 410 (10000 ASA) Keine Vorbelichtung Phosphor Typ P31 (GH)
Gesamte Beschleunigungsspannung	10 kV	Gestrichelte linien
Raster	8 x 10 cm Teilung mit Untereinteilung von 2 mm an den mittleren Achsen	bei 10 % und 90 % des Messrasters, zur Messung von Anstiegzeiten.
Rasterbeleuchtung	Stetig regelbar	Max. Helligkeit bei normalen Laborbeleuchtungsbedingungen deutlich sichtbar.
1.2.2. Vertikalablenkung (Y)		
Anzahl Kanäle	4	Vier mit A, B, C und D bezeichnete Kanäle
Darstellungsarten	Kanal A allein Kanal B allein Kanal C allein Kanal D allein Kanäle A+B addiert Kanäle C+D addiert jede dieser Arten in beliebiger Kombination, gechopped oder alternierend dargestellt. Alle Kanäle können invertiert werden.	
Darstellungszeit pro Kanal in Chopper-Betrieb	ca. 500 ns.	Ab /03 Version: schaltbar zwischen 0,5 and 2 µs (siehe Fig. 3.47).
Frequenzbereich	DC ... 50 MHz 10 Hz ... 50 MHz	Gleichspannungsgekoppelt Obere Bandbreitegrenze –3 dB Wechselspannungsgekoppelt –3 dB Bandbreitegrenze

Benennung	*Beschreibung*	*Nähere Angaben*
Anstiegzeit	≈ 7 ns	
Überschwingen	± 2 % maximal	Gemessen mit einem Prüfimpuls mit 6 Div. Auslenkung / 1 ns. Anstiegzeit und 1 µs Wiederholungszeit.
Ablenkkoeffizienten	5 mV/DIV ... 2 V/DIV	In neun kalibrierten Stufen in 1-2-5 Folge. Nichtkalibriert, kontinuierlich einstellbar 1 : ⩾ 2.5
Fehlergrenze	± 3 %	
Eingangsspannung	± 400 V maximal	Gleichspannung + Spitzenwert einer Wechselspannung. In den 5 mV/DIV ... 20 mV/DIV Stufen des Eingangsabschwächer, Minderung bei Frequenzen über 500 kHz. Siehe Abb. 1.2.
Maximale Ablenkung	24 DIV ⩾ 6 DIV	Für sinusförmige Signale bis 15 MHz Für sinusförmige Signale von 15 MHz bis 50 MHz
Maximale Gesamtsignal-amplitude in Betriebsarten A-B und C-D	24x Abschwächer Einstellung	Abschwächer in CAL Stellungen
Verschiebungsbereich	16 DIV	
Gleichtaktunterdrückung	⩾ 100:1 bei 1 MHz	Nach Abgleich
Übersprechen zwischen Kanälen	35 dB maximal	Für alle Abschwächerkombinationen Bezogen auf 6 DIV. Signalamplitude (0 ... 50 MHz) Chopper-Betrieb
Bild-Instabilität DC Drift	⩽ 0,3 DIV/Stunde bei 20 °C	Nach 15 Minuten Anwärmzeit
Temperaturdrift	⩽ 60 µV/°C typisch	
Abschwächungsgleichgewicht	⩽ 0,3 DIV	Beim Umschalten zwischen beliebigen Abschwächer-Einstellungen.
Eingangsimpedanz	1 Mohm//15 pF	
Kopplung	AC-0-DC	
RC-Zeit des Eingangs	22 ms	Kopplung-Schalter auf AC
Sichtbare Signalverzögerung	20 ns	

1.2.3. Horizontalablenkung (X)

Darstellungsarten	– Hauptzeitbasis – Hauptzeitbasis aufgehellt durch verzögerte Zeitbasis – verzögerte Zeitbasis – X/Y Betrieb	Bis zu vier X/Y Darstellungen. Betrieb mit X-Ablenkung durch einen der vier Kanäle, ein externes Signal oder das Netzsignal
Frequenzbereich des Horizontal-ablenkungs-Verstärkers	DC ... 1 MHz	über 6 DIV –3 dB obere Bandbreitegrenze
Ablenkkoeffizient	450 mV/DIV Vertikalabschwächkoeffizienten	Bei Anwendung von Eingang EXT Zutreffend wenn einer der vertikalen Kanäle für Horizontalablenkung angewandt wird.
Fehlergrenze	± 10 %	Bei Anwendung eines der vertikalen Kanäle für Horizontalablenkung

Benennung	*Beschreibung*	*Nähere Angaben*
Eingangsimpedanz	1 Mohm//15 pF	
Phasendifferenz zwischen Vertikal- und Horizontalabl. Verstärker	weniger als 3°	bei 100 kHz
Ablenkung durch Netzspannung	8 DIV	Die Ablenkung ist abhängig von der Netzspannung und ist ab Fabrik eingestellt auf 8 DIV bei 220 V Netzspannung.

1.2.4. Hauptzeitablenkung

Betrieb	Automatisch Getriggert Einmalig	Bei Betriebsart AUTO ist die Zeitbasis etwa 100 ms nach Verschwinden des Triggersignals freilaufend.
Zeitmassstäbe	0,5 s/DIV ... 50 ns/DIV	22 kalibrierte Stufen in 1-2-5 Folge. Nichtkalibriert: kontinuierliche Einstellung 1 : ⩾ 2,5
Fehlergrenze	± 3 %	± 5 % für 0,5 s/DIV und 0,2 s/DIV ± 5 % für 100 ns/DIV und 50 ms/DIV

1.2.5. Verzögerte Zeitablenkung — Sofort nach Verzögerungszeit laufend oder triggerbar nach Verzögerungszeit

Zeitmassstäbe	1 ms/DIV ... 50 ns/DIV	14 kalibrierte Stufen in 1-2-5 Folge Nichtkalibriert, Stufenlose Einstellung 1 : ⩾ 2,5
Fehlergrenze	± 3 %	± 5 % für 100 ns/DIV und 50 ns/DIV
Dehnung der Zeitbasis	x 5	
Maximale effektive Schreibgeschwindigkeit	10 ns/DIV	
Zuzügliche Toleranz	± 2 %	

1.2.6. Triggerung der Hauptzeitablenkung

Triggerquelle	Intern Zusammengesetzt Netz Extern	von Kanal A, B, C oder D
Trigger-Bandbreite	DC ... 50 MHz	Obere Bandbreitegrenze –15 dB
Trigger-Empfindlichkeit	Intern ⩽ 0,5 DIV Extern ⩽ 250 mV	0,3 DIV typisch 150 mV typisch
Flankenwahl	+ oder –	
Ext. Triggereingangsimpedanz	1 Mohm//15 pF	Gleich dem Eingang einer beliebigen Vertikalablenkung
Eingangsspannung	± 400 V max.	DC + AC Spitze

1.2.7. Triggerung der verzögerten Zeitablenkung

Gleich der Hauptzeitablenkungstriggerung ausser:

Triggerquelle	Intern Zusammengesetzt	Von Kanal A, B, C oder D

Verzögerte Ablenkung

Verzögerungszeit	Stufenlos regelbar zwischen 0,3x und 10x der Zeitmassstab der Hauptzeitablenkung mit Helipotentiometer	

Benennung	*Beschreibung*	*Nähere Angaben*
Zusätzlicher Verzögerungs-zeitfehler	0,5 %	
Verzögerungszeitjitter	⩽ 1 : 20 000	

1.2.8. **Kalibriereinheit**

Spannung	3 V_{s-s}	Rechtecksignal, Grundlinie ist Null-spannung
Strom	6 mA	Durch Stromkreis
Fehlergrenze	± 1 %	Für Spannung und Strom
Frequenz	2 kHz	± 2 %
Sicherung	Der Ausgang ist kurzschlussfest	

1.2.9. **Speisung**

Netzspannungen	90 ... 270 V Wechselspannung (AC) oder 100 ... 350 V Gleichspannung (DC)	In einem Bereich
Netzfrequenz	46 ... 440 Hz oder DC	
Eingebaute Sicherung	1,6 A, träge	Für alle Netzspannungen
Leistungsaufnahme	29 W	

1.2.10. **Einflussgrössen**

Die angegeben Daten gelten nur dann, wenn das Gerät gemäss den offiziellen Prüfverfahren kontrolliert wurde. Einzelheiten, die dieses Verfahren und die Fehlergrenzenkriterien betreffen, können von der PHILIPS-Organisation Ihres Landes oder von N.V. PHILIPS' GLOEILAMPENFABRIEKEN, TEST AND MEASURING DEPT., EINDHOVEN, HOLLAND angefordert werden.

Umgebungstemperaturen	+5 °C ... +40 °C −10 °C ... +55 °C −40 °C ... +70 °C	Betrieb innerhalb Spezifikation Arbeitsbereich Lagerung und Transport
Höhe	5000 m 15000 m	Betriebsfähig Nicht Betriebsfähig
Feuchtigkeit	Das Gerät entspricht den Anforderungen gemäss IEC 68 Db Standard	
Stossfestigkeit	1000 Stösse von 10 g, ½ Sinus, Dauer 6 ms, in allen 3 Richtungen	I EC 68 E b
Vibration	30 Minuten in jeder der drei Richtungen, 10-150 Hz; 0,7 mm (Spitze-Spitze) und 5 g maximale Beschleunigung	I EC 68 F
Akklimationszeit	30 Minuten für Normalbetrieb	Kommend von −10 °C nach +20 °C bei 60 % relativer Feuchtigkeit
Störgrad	Das Gerät entspricht den Anforderungen gemäss VDE Störgrad K	

1.2.11. **Mechanische Daten**

Abmessungen	Länge 410 mm Breite 316 mm Höhe 154 mm	Ohne Bedienungsorgane, Deckel und Füsse
Gewicht	9,7 kg	

Benennung *Beschreibung* *Nähere Angaben*

1.2.12. Standardzubehör

Kontrastfilterscheibe
Abdeckhaube mit Aufbewahrungsraum
Faltbarer Lichtschutztubus PM 9366
BNC Übergangsstecker PM 9051
CAL Anschlussklemme - BNC Adapter
Anleitung

1.2.13. Wahlzubehör

PM 9335	1:1 Messkopf 1,5 m Kabel	**PM 9355**	12 Hz ... 70 MHz Strom-Messkopf (1 mA/div. ... 1 A/div.)
PM 9335L	1:1 Messkopf 2,5 m Kabel	**PM 9346**	Stromversorgung für aktive Messköpfe
PM 9350	10:1 Messkopf, 11 pF 1,5 m Kabel	**PM 8960**	19" Gestelleinbausatz
PM 9350L	10:1 Messkopf, 14 pF 2,5 m Kabel	**PM 8992**	Zubehörtasche
PM 8927	10:1 Messkopf 1,5 m Kabel	**PM 9380**	Oszillografenkamera
PM 8927L	10:1 Messkopf 2,5 m Kabel	**PM 8971**	Kamera Adapter für PM 9380
PM 9358	100:1 Messkopf, 5600 V maks., 2 pF, 1,5 m Kabel	**PM 8910**	Polaroid Anti-Reflex Filter
		PM 8980	Langer Einblicktubus
		PM 8901	Batteriespeisung 24 V und 330 V Gleichspannung
		PM 8991	Rollwagen
PM 9347	Aktiver T.V. Messkopf, 10:1, 11 pF		
PM 9352	Aktiver 10:1 Miniaturmesskopf 100 kohm//6 pF		
PM 9353	Aktiver FET-Messkopf, 10:1, 100:1 1 Mohm//3,5 pF		

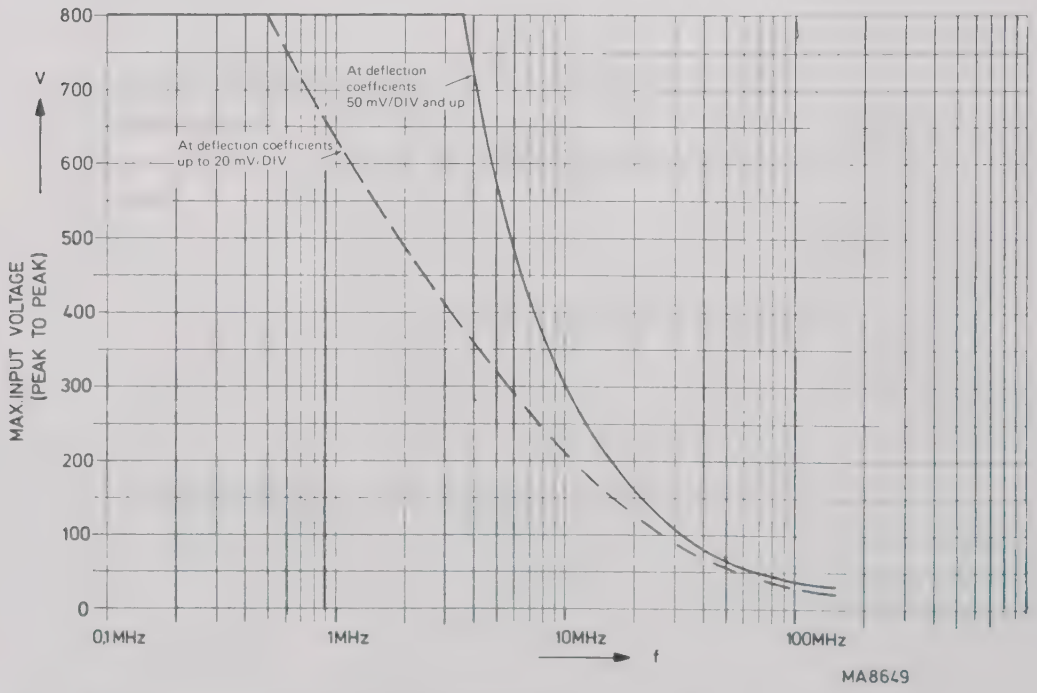

Abb. 1.2. Minderung der höchstzulässigen Eingangsspannung als Funktion der Frequenz

Abb. 2.1. Abnehmen der Abdeckhaube

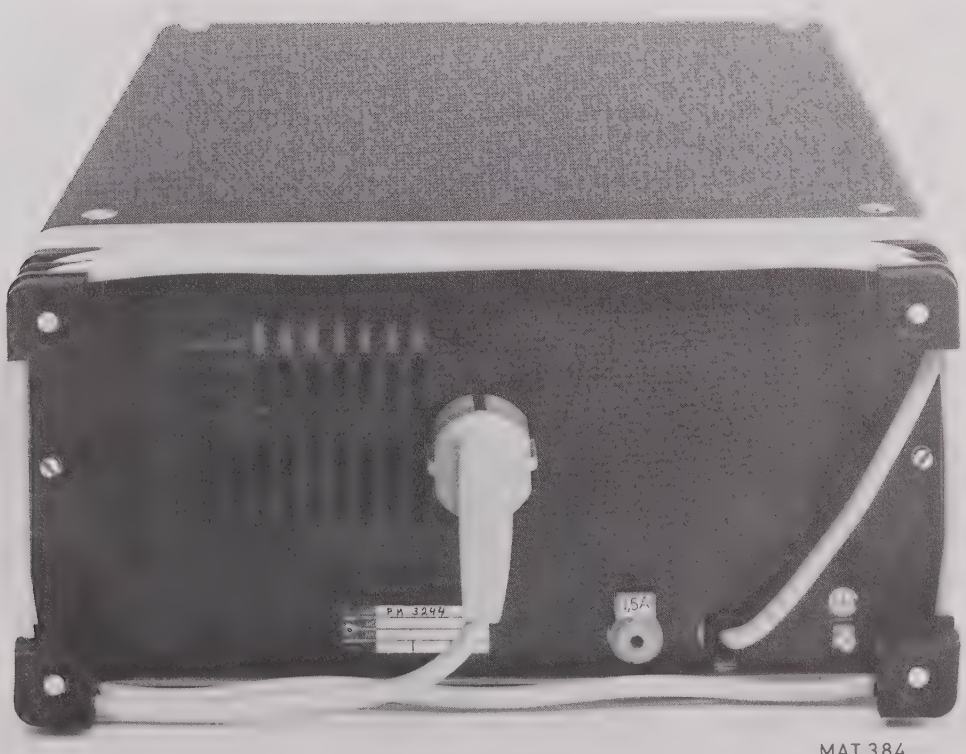

Abb. 2.2. Rückansicht des Gerätes

2.Gebrauchsanleitung

2.1. INBETRIEBNAHME

2.1.1. Abnehmen und Aufsetzen der Abdeckhaube (Abb. 2.1.)

Abnehmen:
- Den Knopf in der Mitte des Deckels eine viertel Umdrehung nach links drehen (Stellung UNLOCKED).
- Deckel abnehmen.

Aufsetzen:
- Den Verriegelungsknopf in Stellung UNLOCKED drehen.
- Deckel an der Vorderseite des Oszillografen befestigen.
- Knopf eindrücken und eine viertel Umdrehung nach rechts drehen (Stellung LOCKED).

Bemerkung: Der Handgriff lässt sich drehen wenn die Druckknöpfe auf ihren Lagern eingedrückt werden.

WARNUNG: In diesem Gerät werden hohe Spannungen erzeugt, deshalb darf es niemals in geöffnetem Zustand eingeschaltet werden.
Vor Wartungsarbeiten ist der Netzstecker zu ziehen und ist darauf zu achten dass alle Hochspannung führenden Teile entladen sind.
Bevor irgend eine Verbindung ausgeführt wird muss die Erdanschlussklemme an einen Schutzleiter angeschlossen werden (siehe Abschnitt "Erdung").

2.1.2. Netzspannungseinstellungen und Sicherung

Da das Gerät bei jeder Netzspannung zwischen 90 und 270 V Wechselspannung und zwischen 100 und 350 V Gleichspannung betriebsfähig ist, erübrigt sich das Umschalten auf die örtliche Netzspannung.
Der Sicherungshalter ist an der Rückwand angebracht. Die Sicherung 1,6 A, träge wird bei allen Netzspannungen angewandt.
Es dürfen nur die vorgeschriebenen Sicherungen verwendet werden. Die Verwendung reparierter Sicherungen und das Kurzschliessen des Sicherungshalter sind nicht zulässig. Das Gerät muss von allen Spannungsquellen getrennt sein wenn eine Sicherung ersetzt wird.

2.1.3. Erdung

Vor dem Einschalten muss dass Gerät auf eine der folgenden Weisen mit einem Erdschutzleiter verbunden werden:
- über den Erdanschluss (gekennzeichnet ⏚).
- über das dreiadrige Netzkabel. Der Netzstecker darf nur in eine Schutzkontaktdose eingeführt werden. Diese Schutzmassnahme darf nicht unwirksam gemacht werden, z.B. durch Verwendung einer Verlängerungsleitung ohne Schutzleiter.

WARNUNG: Jede Unterbrechung des Schutzleiters innerhalb oder ausserhalb des Geräts ist unzulässig.
Wenn ein Gerät von kalter in warme Umgebung gebracht wird, kann dies zu einem sicherheitstechnisch gefährlichen Zustand führen. Deshalb sind alle Erdungsvorschriften sorgfältig zu beachten.

2.1.4. Öffnen des Geräts

Beim Öffnen von Abdeckungen oder Entfernen von Teilen mit Werkzeug können spannungsführende Teile freigelegt werden. Auch können Anschlussstellen spannungsführend sein.

Vor dem Öffnen des Geräts muss das Gerät von allen Spannungsquellen getrennt sein. Wenn danach eine Kalibrierung, Wartung oder Reparatur am geöffneten Gerät unter Spannung unvermeidlich ist, so darf das nur durch eine Fachkraft geschehen, welche die damit verbundenen Gefahren kennt.

Ersetzen des Netzsteckers geschieht auf eigene Gefahr. Nach dem Ersetzen des Netzsteckers ist es ratsam einen Hochspannungstest IEC 348 vorzunehmen.

Kondensatoren im Gerät können noch geladen sein, selbst wenn das Gerät von allen Spannungsquellen getrennt wurde.

2.1.5. Einschalten

Der Netzschalter POWER ist gekoppelt mit der Rasterbeleuchtungseinsteller ILLUM und befindet sich an der Vorderseite des Gerätes unter dem Bildröhrenrahmen.
Der Oszillograf darf niemals eingeschaltet werden, wenn eine Leiterplatte oder Baustein entfernt wurde.
Eine Leiterplatte oder Baustein darf nicht früher als eine Minute nach Ausschaltung des Gerätes entfernt werden.

2.2. BEDIENUNGSORGANE UND BUCHSEN

2.2.1. Vertikalablenkung (Y)

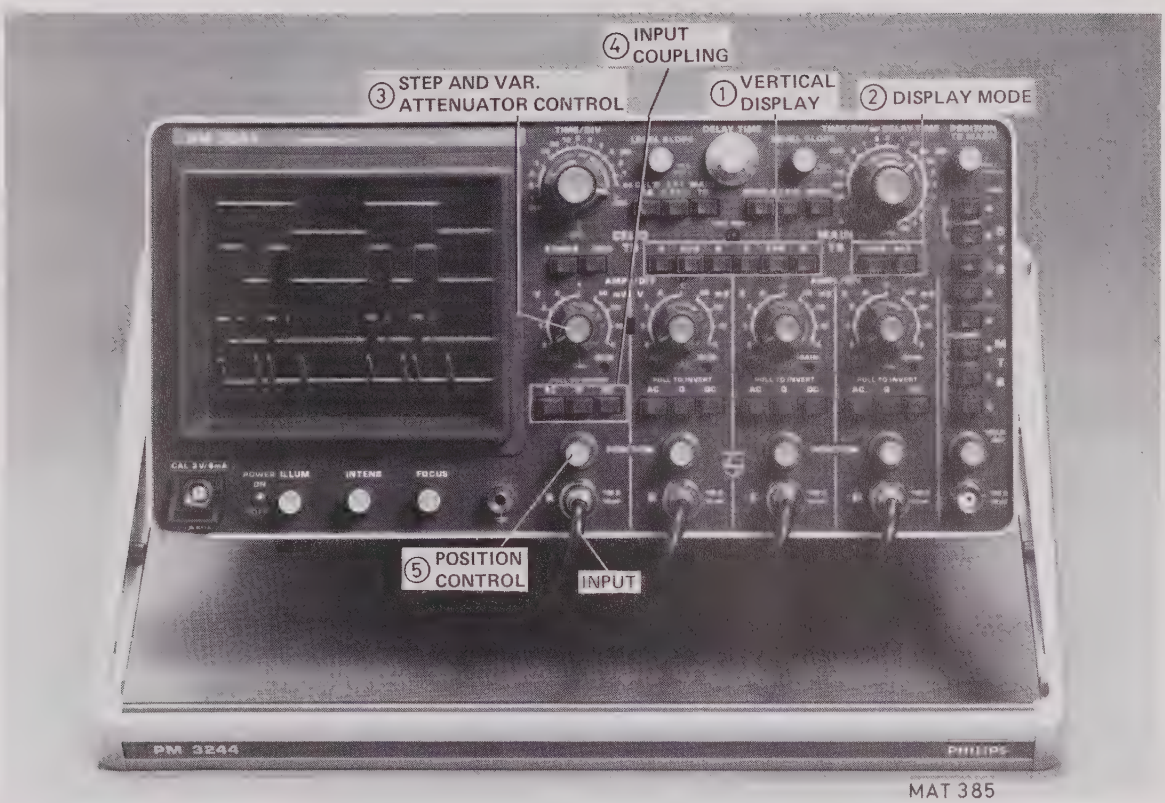

Abb. 2.3. Vertikalablenkung

1. Vertikalablenkungsart-Schalter

Taste A	Kanal A
Tasten A+B	Kanäle A und B algebraisch addiert
Taste B	Kanal B
Taste C	Kanal C
Tasten C+D	Kanäle C und D algebraisch addiert
Taste D	Kanal D

Jede Kombination obiger Darstellungsarten ist möglich.
Wenn keine Taste gedrückt ist, ist Kanal A eingeschaltet.

2. Darstellungsart Schalter CHOP/ALT

Die in Punkt 1 erwähnten Kanäle können gechopped oder alternierend dargestellt werden. Wenn keine Taste gedrückt ist und zwei oder mehr Kanäle eingeschaltet sind, dann ist die Darstellung gechopped.

3. Abschwächer-Einsteller

AMPL/DIV	Stufenweise Einstellung der Ablenkkoeffizienten, kombiniert mit:
AMPL/CAL	Stufenlose Einstellung der Ablenkkoeffizienten. Wenn dieser Knopf gezogen ist, wird die Polarität des Kanals invertiert.
4. Eingangskopplung-Schalter	AC Signalkopplung über einen Sperrkondensator O Kanaleingang geerdet, Signalleerlauf DC Direkte Kopplung (Wenn keine Taste eingedrückt ist, ist Einstellung AC wirksam.)
5. POSITION	Stufenlose Einstellung bewirkt vertikale Verschiebung des betreffenden Kanals.

VOREINSTELL-BEDIENUNGSORGANE

BAL	Ausgleich des Stufenabschwächergleichgewichtes
GAIN	Verstärkereinstellung des Stufenabschwächers

2.2.2. Horizontalablenkung (X)

Abb. 2.4. Horizontalablenkung

1. Horizontalablenkungsart-Schalter

MAIN TB	Die Horizontalablenkung wird vom Hauptzeitablenkgenerator bewirkt. Ein Teil der Darstellung wird aufgehellt wenn die verzögerte Zeitablenkung eingeschaltet ist.
EXT X DEFL	Horizontalablenkung wird bewirkt durch ein Signal kommend von: – der Eingangsbuchse des Horizontalverstärkers (3) – einem der vertikalen Kanäle (4) – dem Netz (4).
DEL'D TB	Die Horizontalablenkung wird vom verzögerten Zeitablenkgenerator bewirkt. Wenn keine Taste eingedrückt ist, dann gilt MAIN TB.

2. Position und Dehnung der Zeitablenkung

POSITION	Stufenlose Einstellung der horizontalen Verschiebung der Darstellung.
TB MAGN	Zug-Druck Schalter für 5-fache Steigerung der Zeitablenkkoeffizienten.

2.2.3. Hauptzeitablenkung

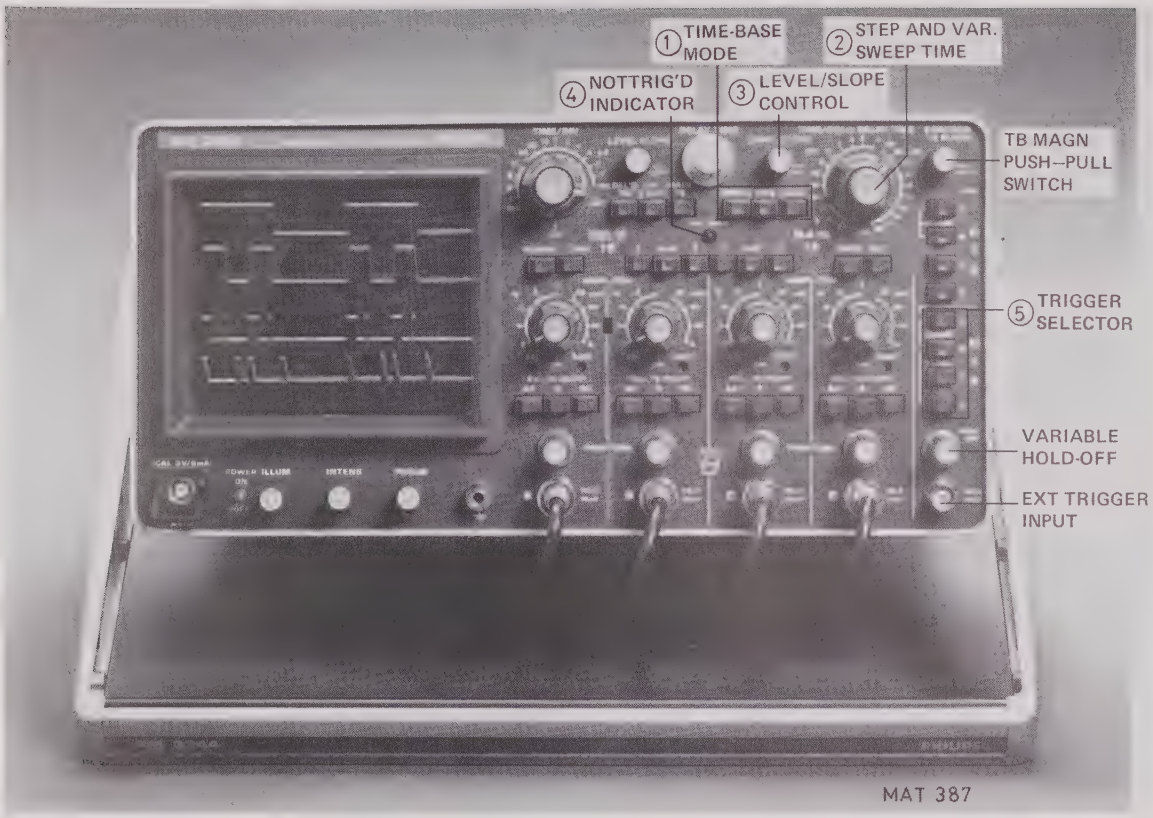

Abb. 2.5. Hauptzeitablenkung

1. Hauptzeitablenkung-Wahlschalter

AUTO	Wenn keine Triggerimpulse vorhanden sind, ist der Hauptzeitablenkgenerator freilaufend.
TRIG	Die Hauptzeitablenkung wird auf normale Weise getriggert.
SINGLE	Single sweep Zeitablenkung. Nach Betätigung der Taste Single läuft der Hauptzeitablenkgenerator nur einmal ab. Wenn keine Taste eingedrückt ist, arbeitet die Zeitablenkung in Betriebsart Single Sweep.

2. Schalter TIME/DIV or DELAY — Stufenweise Einstellung der Zeitkoeffizienten der Hauptzeitablenkung; Drehschalter mit 22 Stellungen. Wenn die verzögerte Zeitablenkung wirksam ist, dann ist die Verzögerungszeit nach der die verzögerte Zeitablenkung startet gegeben durch die Einstellung der Helipotentiometer "DELAY TIME" mal TIME/DIV Koeffizient dieses Schalters.

TIME/DIV CAL	Stufenlose Einstellung des Zeitkoeffizienten.

3. LEVEL/SLOPE — Stufenlose Einstellung zur Wahl des Triggerpegels bei welchem der Zeitablenkgenerator startet. Der Zug-Druckschalter gestattet Wahl der Triggerung auf der positiv oder negativ gerichteten Flanke des Signals.

4. Anzeige NOT TRIG'D — Leuchtet auf wenn keine Triggerung des Hauptzeitablenkgenerators erfolgt ist.

5. Hauptzeitablenkung Triggerquelle-Wahlschalter — Dieser Schalter besteht aus vier Tasten (A, B, C, D) für die Wahl des Triggersignals von einem der Vertikalablenkungskanäle. Wenn die beiden Tasten A und B eingedrückt sind, wird das zusammengesetzete Triggersignal gewählt. Wenn die beiden Tasten B und C eingedrückt sind, wird ein Teil der Netzspannung als Triggersignal verwendet.
Wenn die beiden Tasten C und D eingedrückt sind, wird das Signal welches an Buchse EXT liegt als Triggersignal verwendet. Falls keine Taste eingedrückt ist, ist Signal A eingeschaltet.

2.2.4. Verzögerte Zeitablenkung

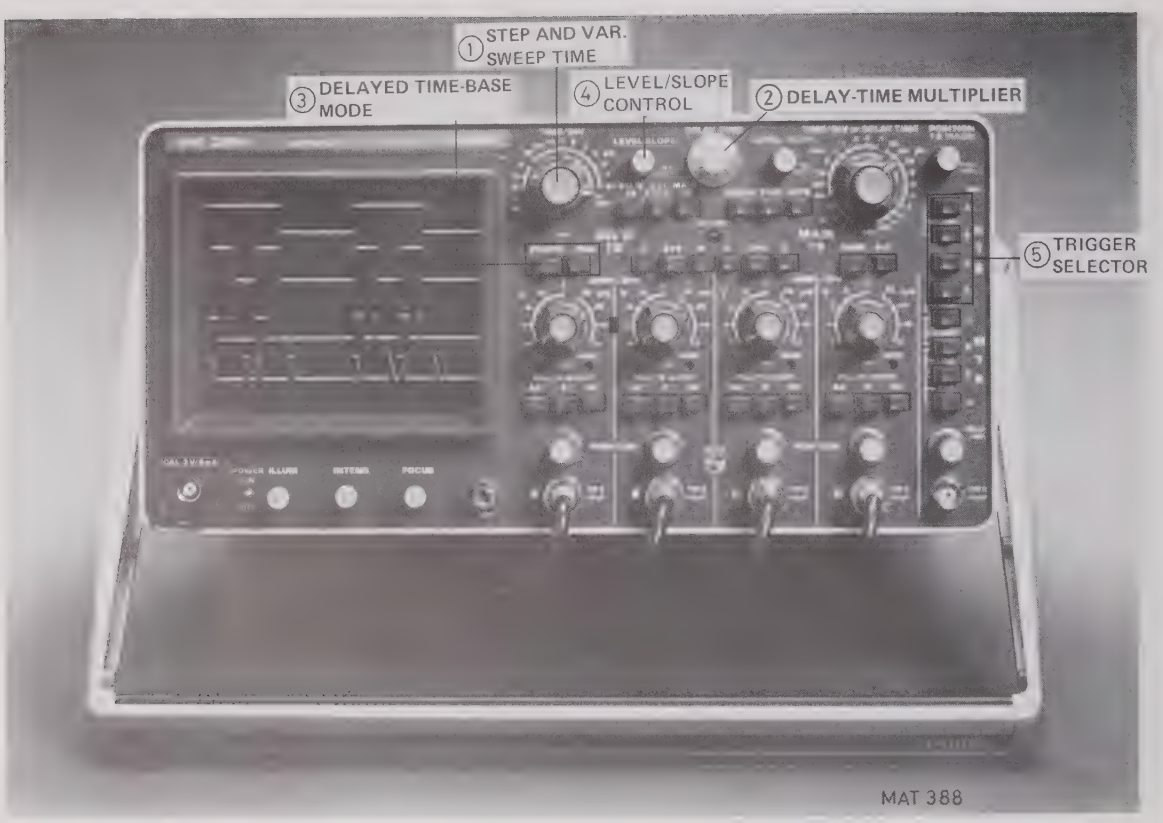

Abb. 2.6. Verzögerte Zeitablenkung

1. Schalter TIME/DIV	Stufenweise Einstellung der Zeitkoeffizienten der verzögerten Zeitablenkung: Drehschalter mit 14 Stellungen. In Stellung OFF wird die verzögerte Zeitablenkung abgeschaltet.
TIME/DIV CAL	Stufenlose Einstellung der Zeitkoeffizienten der Zeitablenkung.
2. DELAY TIME	Kalibrierter Helipotentiometer zur Einstellung der Verzögerungszeit, nach welcher der verzögerte Zeitablenkgenerator wirksam wird. Diese Verzögerungszeit ist gegeben durch die Einstellung DELAY TIME mal TIME/DIV Koeffizient der Hauptzeitablenkung.
3. STARTS/TRIG	Wenn Taste STARTS eingedrückt ist, startet sofort nach der Verzögerungszeit die verzögerte Zeitablenkung (die verzögerte Zeitablenkung erfordert in diesem Falle kein Triggersignal). Wenn Taste TRIG eingedrückt ist startet die verzögerte Zeitablenkung nach der Verzögerungszeit nach Empfang eines Triggerimpulses. Keine Taste gedrückt hat die gleiche Wirkung wie Taste STARTS gedrückt.
4. LEVEL/SLOPE	Stufenlose Einstellung zur Wahl des Triggerpegels bei welchem der verzögerte Zeitablenkgenerator getriggert wird. Der Zug-Druck Schalter gestattet Wahl der Triggerung auf der positiv oder negativ gerichteten Flanke des Signals.
5. Verzögerte Zeitablenkung Triggerquelle-Wahlschalter	Dieser Schalter besteht aus vier Tasten (A, B, C und D) für die Wahl des Triggersignals von einem der Vertikalablenkungskanäle. Wenn die beiden Tasten A und B eingedrückt sind, wird das zusammengesetzte Triggersignal gewählt. Falls keine Taste eingedrückt ist, ist Signal A eingeschaltet.

2.2.5. Bildteil

1. POWER/ILLUM	Stufenlose Einstellung der Rasterbeleuchtung, kombiniert mit Ein/Aus-Netzschalter. Signallampe zeigt Betriebszustand (ON) an.
2. INTENS	Stufenlose Einstellung der Bildhelligkeit
3. FOCUS	Stufenlose Einstellung der Fokussierung des Elektronenstrahls.

Verschiedenes

1. CAL	Ausgangsbuchse für die Kalibrierung: – der Verstärkung des Vertikalablenkverstärkers – der Frequenzkompensation von Abschwächer-Messköpfen. Geeignet für Spannungs-Messköpfe und Strommessköpfe.

2.3. GRUNDEINSTELLUNGEN

Bevor mit dem Oszillografen Messungen ausgeführt werden, muss man sich überzeugen dass der Stufenabschwächer-Ausgleich und die Verstärkungskalibrierung für alle Kanäle einwandfrei eingestellt sind.
Falls erforderlich, wie folgt handeln:

1. Einstellen des Stufenabschwächer-Gleichspannungsgleichgewichts
   – Taste MAIN TB des Horizontalablenkungsschalters eindrücken.
   – Taste AUTO des Hauptzeitablenkungsschalters eindrücken.
   – Mit Einstellern INTENSITY und FOCUS die Bildschärfe adjustieren.
   – Die entsprechende Kanaltaste des Vertikalablenkungsschalters eindrücken.
   – Taste 0 des Eingangskopplungsschalters eindrücken.
   – Mit Knopf POSITION das Bild derart einstellen, dass es sich ungefähr in der Mitte des Schirms befindet.
   – Den stufenlosen Einsteller AMPL auf CAL stellen.
   – Es ist darauf zu achten dass beim Drehen des Stufenschalters AMPL das Bild nicht springt.
     Wenn nötig, Regler BAL einstellen.
   – Den Vorgang für jeden Kanal wiederholen.
2. Verstärkungskalibrierung
   Wenn nicht anders erwähnt befinden sich die Einstellelemente in den gleichen Stellungen wie beim vorgehenden Verfahren.
   – Schalter AC-0-DC auf AC stellen.
   – Schalter AMPL auf 0,5 V und den stufenlosen Einsteller auf CAL stellen.
   – Kanaleingang mit Ausgang CAL verbinden.
   – Kontrollieren ob die Vertikalablenkung genau 6 Div. beträgt. Nötigenfall Regler GAIN adjustieren.
   – In diese Kalibrierung kann ein Abschwächer-Messkopf einbezogen werden. Der Abschwächfaktor des Messkopfs muss in Bezug auf die Stellung des Schalters AMPL in Betracht gezogen werden.
   – Den Vorgang für jeden Kanal wiederholen.

Abb. 2.7.

2.4. BEDIENUNGSANLEITUNGEN

2.4.1. Allgemeines

Vor dem Einschalten überzeuge man sich ob der Oszillograf einwandfrei den INBETRIEBNAHME Vorschriften gemäss (Abschnitt 2.1.) installiert ist und dass die erwähnten Sicherheitsmassnahmen eingehalten wurden.

2.4.2. Vertikalablenkung

Zur Darstellung der gewünschten Kanäle die entsprechenden Tasten des Vertikalablenkungsschalters eindrücken. Wenn zwei oder mehr Bildsignale dargestellt werden, kann die Darstellung in alternierender oder gechoppter Betriebsart erfolgen. In der alternierenden Betriebsart werden die Kanäle hintereinander dargestellt; beim Rücklauf der Hauptzeitablenkung wird die Darstellung von einem Kanal auf den anderen umgeschaltet.

In der gechoppten Betriebsart werden die Kanäle während der Zeitablenkung von einem auf den anderen umgeschaltet. In der gechoppten Betriebsart ist die Darstellungszeit ca. 500 ns pro Kanal. Ab /03 Version; 0,5 und 2 μs, schaltbar, siehe Abb. 3.47.
Für eine gute Darstellung ist es üblich bei höheren Ablenkgeschwindigkeiten die alternierende Betriebsart anzuwenden und bei niedrigeren Ablenkgeschwindigkeiten die gechoppte.
Es ist zu beachten dass bei zusammengesetzter Triggerungsart die alternierende Darstellung gewählt wird, weil sonst die Chopperimpulse die Triggerschaltung beeinflussen.
Die zu beobachtenden Signale sind an die Buchse (n) A ... D zu legen und der AC/0/DC Schalter ist abhängig von der Zusammensetzung der Signale auf AC oder DC zu stellen. Da der vertikale Verstärker gleichspannungsgekoppelt ist, ist die ganze Bandbreite des Gerätes verfügbar und die Gleichspannungskomponenten werden in Stellung DC des AC/0/DC-Schalters als Bildverschiebungen sichtbar.
Sind kleine Signale hohen Gleichspannungen überlagert kann dies störend sein. Jede Abschwächung des Signals verursacht auch eine Abschwächung der kleinen Wechselspannungskomponenten. In diesem Falle ist der Eingangsschalter in AC Stellung zu bringen wodurch ein Sperrkondensator die Gleichspannungs- und Niederfrequenz-Signale unterdrückt. Dies hat Dachschräge zur Folge bei Darstellungen von Niederfrequenzsignalen. Stellung 0 unterbricht das Signal und erdet den Verstärkereingang um den 0 V Pegel schnell bestimmen zu können.
Mit Hilfe der Einsteller POSITION lässt sich die Darstellung in vertikaler Richtung verschieben. Es ist zu beachten, dass bei zusammengesetzter Triggerungsart der Trigger-Startpunkt von der vertikalen Verschiebung beeinflusst wird.

2.4.3. Horizontalablenkung

Abhängig von der Stellung des Horizontalablenkungsschalters ist folgende Horizontalablenkung möglich:
- Hauptzeitablenkung
- Ext. X-Ablenkung
- Verzögerte Zeitablenkung

Mit Einsteller POSITION kombiniert mit der Dehnung der Zeitablenkung kann die Darstellung in horizontaler Richtung verschoben werden.

Wenn Taste MAIN TB oder DEL'D TB eingedrückt ist, wird die Horizontalablenkung von der Hauptzeitablenkung bezw. der verzögerten Zeitablenkung bewirkt. Wenn Taste EXT X DEFL eingedrückt ist, wird Horizontalablenkung bewirkt durch:
- Einen der Vertikalablenkungskanäle A, B, C oder D
- Netzspannung
- Extern über Buchse EXT

2.4.4. Hauptzeitablenkung

Lineare Horizontalablenkung ist verfügbar wenn Taste MAIN TB der Horizontaldarstellungsschalter eingedrückt ist.
Die Betriebsart der Zeitablenkung ist mit den folgenden Schaltern wählbar:

AUTO — Zeitablenkung freilaufend, auch wenn keine Triggerimpulse anliegen. Folglich ist das Bild immer sichtbar.
Betriebsart AUTO kann in allen Fällen verwendet werden, in welchen auch Betriebsart TRIG anwendbar ist, ausgenommen bei Signalfrequenzen niedriger als 10 Hz oder Impulsreihen mit einer "AUS" Zeit über 100 ms. Sobald Triggerimpulse vorhanden sind, wird der Freilauf der Zeitablenkung automatisch beendet und wird der Zeitablenkgenerator normal getriggert.

TRIG — Die Zeitablenkung wird sichtbar sobald Triggerimpulse vorhanden sind und die Triggerpegeleinstellung korrekt ist.

SINGLE — Die Zeitablenkung läuft nach Empfang eines Triggerimpulses nur einmal ab. Nach diesem "Sweep" muss die Zeitablenkung durch Eindrücken der Taste SINGLE erneut eingestellt werden.
Wenn einmalige Vorgänge beobachtet (und in der Regel fotografiert) werden müssen, ist es oft wünschenswert dafür zu sorgen, dass nur ein Sägezahn erzeugt wird, selbst wenn möglicherweise nach Darstellung dieses Vorgangs mehrere Triggerimpulse erzeugt würden.

2.4.5. Triggerung

Wenn ein oder mehrere Signale dargestellt werden sollen, muss um ein stillstehendes Bild zu erhalten, die Zeitablenkung immer an einem festen Punkt des Signals gestartet werden.
Der Zeitablenkgenerator wird deshalb von Triggerimpulsen gestartet, die abhängig von der Stellung des Hauptzeitbasis-Triggerquelle-Wahlschalter, folgenden Signalquellen entstammen:

- Einer der Vertikalablenkungskanäle A, B, C oder D
- Zusammengesetztes Signal
- Netzspannung
- Externe Spannung

Die Amplitude der Triggersignale von einem der Vertikalablenkungskanäle, oder vom zusammengesetzten Signal ist proportional zur Vertikalablenkung des Bildes und daher von der Einstellung des Eingangsabschwächer abhängig.

Für zusammengesetzte Triggerung müssen die Taste A und B eingedrückt werden. Bei dieser Betriebsart wird das Triggersignal dem gemeinsamen Vertikalablenkungsverstärker entnommen.
Zusammengesetzte Triggerung ermöglicht:

a. Triggerung durch Differenzsignale, mit beispielsweise dem Gerät in Betriebsart A+B und mit einer der Eingangsspannungen invertiert.
b. Darstellung von zwei bis vier Signalen mit verschiedenen Frequenzen ohne Beziehung zueinander.
   In diesem Fall müssen die Triggerpunkte der verschiedenen Signale im gleichen Triggerpegelbereich liegen.

Bemerkung: — *Bei Triggerung in der zusammengesetzten Betriebsart, muss die Darstellung immer in Betriebsart ALT erfolgen.*
In Betriebsart CHOP wirken die Chopper-Impulse als Triggerimpulse und verursachen dadurch ein unstabiles Bild.
— *Bei zusammengesetzter Triggerung wird der Triggerpunkt des Signals auch vom Vertikaleinsteller POSITION bestimmt. Eine kleine Modifikation für "AC" zusammengesetzte Triggerung löst dieses Problem. Beschreibung (nur in Englisch) im Abschnitt 3.2.2.*

Netztriggerung wird durch Eindrücken der beiden Tasten B und C bewirkt.
Die Hauptzeitablenkung wird von einem Teil der Netzspannung getriggert. Die Kopplung mit der Netzspannung wird mit Hilfe einer optischen Trennschaltung erlangt, dadurch bleibt das Gerät von der Netzspannung isoliert.
Externe Triggerung wird durch Eindrücken der beiden Tasten C und D bewirkt.
Die Hauptzeitablenkung wird nun von einem an BUCHSE EXT angelegten externen Signal getriggert.
Mit Einsteller LEVEL ist der Triggerpunkt auf der Flanke des Signals wählbar.
Der Zug-Druck Schalter SLOPE erlaubt die Wahl der positiv oder negativ gerichteten Flanke.
Wenn der Hauptzeitbasisgenerator keine Triggerimpulse erhält, dann leuchtet Anzeige NOT TRIG'D auf.

Im SINGLE SWEEP-Betrieb leuchtet diese Anzeige wenn der Zeitablenkgenerator erneut eingestellt wurde und das Erscheinen des nächsten Triggerimpulses erwartet.

Die Ablenkzeit der Hauptzeitablenkung wird mit Knopf TIME/DIV or DELAY TIME eingestellt. Wenn die verzögerte Zeitablenkung eingeschaltet ist, dann ist die Zeit zwischen dem Start der Hauptzeitablenkung und der verzögerten Zeitablenkung vom Produkt der Einstellung des 10-Drehungsknopfes DELAY TIME mal der Einstellung des Ablenkzeitschalters MAIN TB gegeben.

Mit dem inneren Knopf lassen sich Zeitablenkzeiten zwischen den Stufen einstellen. Für Zeitmessungen muss dieser Knopf immer auf CAL stehen.
Der Koeffizient TIME/DIV der Zeitablenkung lässt sich durch Ziehen des Zug-Druck Schalters TB MAGN 5-fach dehnen.

Mit Einsteller HOLD OFF lässt sich die Sperrzeit des Hauptzeitablenkgenerators variieren. Dies ist die Zeit die der Zeitablenkgenerator benötigt bis er zum Empfang des nächsten Triggerimpulses bereit ist. Einsteller HOLD OFF ermöglicht eine stabile Darstellung von komplizierteren Signale, z.B. periodische Doppelimpulse. Der normale Stand des Einstellers HOLD OFF ist Rechtsanschlag. Linksdrehung erweitert die Sperrzeit.

2.4.6. Verzögerte Zeitablenkung

Wenn Taste MAIN TB des Schalters für die horizontale Darstellung eingedrückt ist und der Knopf TIME/DIV der verzögerten Zeitablenkung nicht in Stellung OFF ist, wird ein Teil der Hauptzeitablenkungslinie zusätzlich aufgehellt.
Der Zeitpunkt des Starts der verzögerten Zeitablenkung wird von den Einstellungen des Knopfs TIME/DIV der Hauptzeitablenkung und des 10-Drehungsknopfes DELAY TIME bestimmt. Wenn Taste STARTS des Schalters

der verzögerten Zeitablenkungsart eingedrückt ist, dann startet die verzögerte Zeitablenkung sofort nach der Verzögerungszeit.
Wenn Taste TRIG eingedrückt ist startet die verzögerte Zeitablenkung nach der Verzögerungszeit und nach Erhalt eines Triggerimpulses.
Der Triggerwähler der verzögerten Zeitablenkung besitzt die gleichen Möglichkeiten wie der Triggerwähler der Hauptzeitablenkung mit Ausnahme von LINE und EXT Triggerart.
Die Funktion des Einstellers LEVEL/SLOPE ist die gleiche wie für die Hauptzeitablenkung beschrieben.
Die Zeitdauer des zusätzlich aufgehellten Teils der Hauptzeitablenkung wird von der Einstellung des Knopfs TIME/DIV der verzögerten Zeitablenkung bestimmt.
Mit dem inneren Knopf lassen sich die Ablenkzeiten zwischen den Stufen einstellen. Für Zeitmessungen muss dieser Knopf immer auf CAL gestellt werden.
Wenn Taste DEL'D TB der horizontalen Darstellung eingedrückt ist wird der zusätzlich aufgehellte Teil über die gesamte Schirmbreite sichtbar gemacht.

Notice d'emploi

1. Generalites

1.1. INTRODUCTION

L'oscilloscope portatif haute fréquence PM 3244 présente quatre voies identiques de déviation verticale à haute sensibilité (5 mV/div) et sur une largeur de bande étendue de 50 MHz.

Il y a un large choix de déviations verticales possibles: une, deux, trois ou quatre voies (alternées ou découpées). De plus, les deux premières voies peuvent être additionnées et aussi les deux dernières voies. La polarité de chaque voie peut être inversée.

Pour ce qui est des déviations horizontales possibles, on distingue: la déviation de base de temps principale (avec ou sans base de temps retardée intensifiée), la déviation de base de temps retardée ou la déviation externe.

Si l'on excepte la source de déclenchement normal, le PM 3244 offre un déclenchement composite.

Cet oscilloscope se caractérise par une alimentation à faible dissipation fonctionnant pour une tension alternative entre 90 et 270 V ou pour une tension continue entre 100 et 350 V.

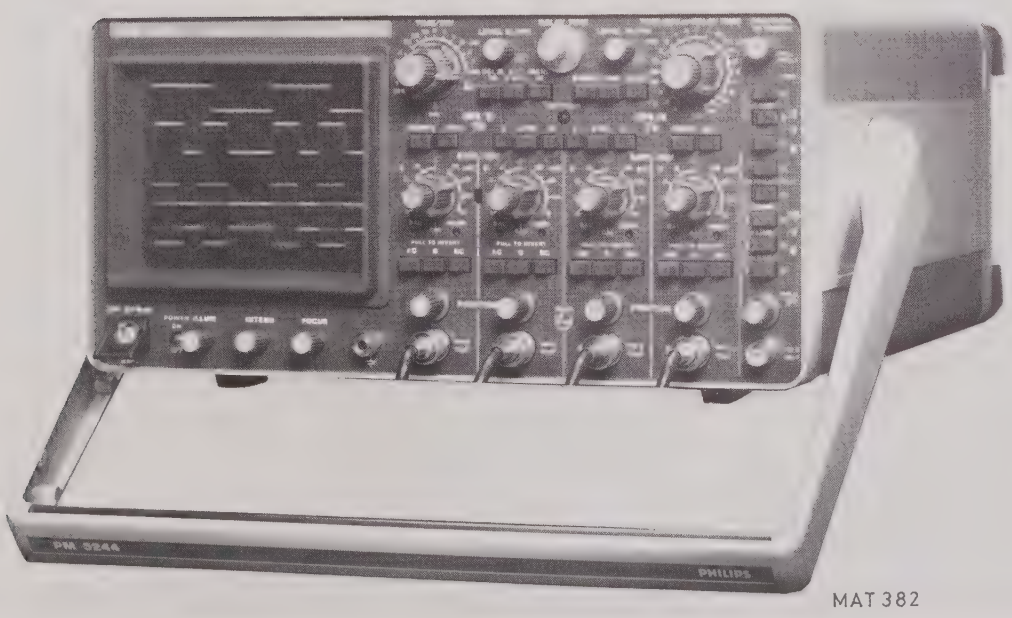

Fig. 1.1. Oscilloscope portatif à quatre voies PM 3244

1.2. CARACTERISTIQUES TECHNIQUES

Les spécifications sont valables après que l'appareil a été préchauffé pendant 30 minutes.
Les valeurs indiquées avec tolérance sont garanties. Les chiffres sans tolérance ne servent qu'à titre d'information et correspondant aux charactéristiques d'un appareil moyen.

Cet appareil a été conçu et testé conformément à la norme C.E.I. 348 pour appareils de classe I. A sa livraison il répond aux règles de sécurité. La présente notice comporte les informations et les avertissements nécessaires à l'utilisateur afin d'assurer le fonctionnement de l'appareil dans les conditions de sécurité et de le maintenir conforme à la norme.

Désignation	*Spécification*	*Information supplémentaire*
1.2.1. Tube à rayons cathodiques		
Type	PHILIPS D14-125 GH/37	Tube à face rectangulaire, type domed mesh, post-accélérateur, couche phosphore doublée de métal
Aire de mesure	80 mm x 100 mm	8 x 10 divisions
Type d'écran	Phosphore P31 (GH)	en option, couche phosphore P11 (BE) ou P7 (GM)
Vitesse d'écriture photographique	750 cm/μs	Mesuré avec un appareil photographique Steinheil Oscillophot M5 Ouverture: 1:1,2 Rapport objet/image: 1:0,5 Film: Polaroid 410 (10000 ASA) pas de pré-voilage Phosphore du type P31 (GH)
Tension d'accélération totale	10 kV	
Graticule	Divisions 8 x 10 cm avec subdivisions de 2 mm sur les axes centraux.	Les lignes interrompues indiquent les points 10 % et 90 % pour la mesure du temps de montée.
Illumination de graticule	Continuellement variable	Luminosité maximale nettement visible dans les conditions d'éclairage normales de laboratoire.
1.2.2. Déviation verticale (Y)		
Nombre de voies	4	Quatre voies identiques, A, B, C et D
Modes d'affichage	Voie A seulement Voie B seulement Voie C seulement Voie D seulement Voies A+B additionnées Voies C+D additionnées Ces modes peuvent tous être découpés ou alternés. Toutes les voies peuvent être inversées.	
Temps d'affichage par voie en mode découpé	Environ 500 ns	A partir de la version /03: 0,5 ou 2 μs, commutable. (Voir fig. 3.47).
Gamme de fréquence	Continu à 50 MHz	Couplage continu Largeur de bande supérieure –3 dB
	10 Hz à 50 MHz	Couplage capacitif Largeur de bande supérieure –3 dB
Temps de montée	$\approx$ 7 ns	
Dépassement	$\pm$ 2 % max.	Impulsion d'essai avec temps de montée 1 ns, déviation de 6 divisions et temps de répétition de 1 μs

Désignation	*Spécification*	*Information supplémentaire*
Coefficients de déviation	5 mV/DIV à 2 V/DIV	En 9 positions étalonnées (progression 1-2-5), avec commande non-calibrée continue 1: ⩾ 2,5 par potentiomètre
Précision	± 3 %	
Tension d'entrée	± 400 V max.	Tension continue + crête de tension alternative. En positions 5 mV/DIV à 20 mV/DIV de l'atténuateur d'entrée réduction de la tension d'entrée maximale admise à fréquences > 500 kHz. Voir Fig. 1.2.
Déviation maximale	24 divisions ⩾ 6 divisions	Pour tensions sinusoïdales jusqu'à 15 MHz Pour tensions sinusoïdales de 15 MHz à 50 MHz
Amplitude totale maxi en modes A-B et C-D	24x réglage d'atténuateur	Atténuateurs en position CAL
Gamme de décadrage	16 divisions	
Réjection en mode commun	⩾ 100:1 à 1 MHz	Après de réglage
Diaphonie entre voies	35 dB max.	Pour toutes combinaisons d'atténuateurs. La référence est 6 div. d'amplitude (0 à 50 MHz), mode découpé.
Instabilité, dérive de trace Dérive de température Balance d'atténuateur	⩽ 0,3 div/h à 20 °C ⩽ 60 µV/°C typique ⩽ 0,3 div	Après 15 min. de pré-chauffage En commutant entre positions d'atténuateur
Entrée		
Impédance	1 Mohm//15 pF	
Couplage	AC-0-DC	
Temps RC	22 msec	Commutateur de couplage sur "AC"
Retard de signal visible	20 nsec	

1.2.3. **Déviation horizontale (X)**

Modes d'affichage	– Base de temps principale – Base de temps principale intensifiée par base de temps de retardée – Base de temps retardée – Fonctionnement X/Y	Fonctionnement X/Y quatre traces avec déviation X par une des 4 voies verticales, un signal externe ou le signal d'alimentation

Amplificateur de déviation horizontale

Largeur de bande	Continue à 1 MHz	Sur 6 divisions Limite supérieure –3 dB
Coefficient de déviation	450 mV/div Coefficients d'atténuateur vertical	A l'aide de l'entrée EXT S'appliquent lorsqu'une des voies verticales est utilisée à la déviation horizontale
Précision	± 10 %	Utilisant un canal vertical pour déviation horizontal
Impédance d'entrée	1 Mohm//15 pF	

	Désignation	*Spécification*	*Information supplémentaire*
	Différence de phase entre ampl. de déviation vert. et ampl. de déviation horizontale	inférieure à 3°	à 100 kHz
	Déviation par tension secteur	8 divisions	La déviation dépend de la tension secteur et est réglé sur 8 DIV pour tension secteur 220 V à l'usine
1.2.4.	**Base de temps principale**		
	Fonctionnement	Automatique Déclenché Balayage unique	En mode automatique, la base de temps est en fonctionnement libre env. 100 ms. après la disparition du signal de déclenchement.
	Coefficients de temps	0,5 s./DIV ... 50 ns./DIV	En 22 positions étalonnées (progression 1-2-5) Commande continue non-étalonnée 1 : ⩾ 2,5
	Précision	± 3 %	± 5 % pour 0,5 s/DIV et 0,2 s/DIV ± 5 % pour 100 ns./DIV et 50 ms./DIV
1.2.5.	**Base de temps retardée**	Démarre immédiatement après le temps de retard ou est déclenchable après le temps de retard	
	Coefficients de temps	1 ms./DIV ... 50 ns./DIV	En 14 positions étalonnées (progression 1-2-5) Commande continue non-étalonnée 1 : ⩾ 2,5
	Précision	± 3 %	± 5 % pour 100 ns./DIV et 50 ns./DIV
	Agrandisseur de base de temps		
	Agrandissement	x5	
	Vitesse de balayage efficace maximale	10 nsec/DIV	
	Tolérance supplémentaire	± 2 %	
1.2.6.	**Déclenchement de la base de temps principale**		
	Source	Interne Composite Secteur Externe	A partir de la voie A, B, C ou D
	Largeur de bande de déclenchement	Continu à 50 MHz	Limite supérieure −15 dB
	Sensibilité de déclenchement	Interne ⩽ 0,5 DIV Externe ⩽ 250 mV	0,3 DIV typique 150 mV typique
	Sélection de pente	+ ou −	
	Impédance d'entrée pour déclenchement externe	1 Mohm//15 pF	Identique pour chaque entrée de déviation verticale
	Tension d'entrée	± 400 V max.	Tension continue + crête de tension alternative

1.2.7. Déclenchement de la base de temps retardée

Identique au déclenchement de la base principale sauf:

Source	Interne Composite	A partir de la voie A, B, C ou D
Retard de balayage		
Temps de retard	Continuellement variable entre 0,3x et ⩾ 10x le coefficient de temps de la base de temps principale	Réglable à l'aide d'un potentiomètre 10-tours
Erreur supplémentaire du temps de retard	0,5 %	
Jitter du temps de retard	⩽ 1 : 20.000	

1.2.8. Unité d'étalonnage

Tension	3 V_{cc}	Onde carrée, ligne de base 0 V
Courant	6 mA	Par le boucle de courant
Précision	± 1 %	Pour la tension et le courant
Fréquence	2 kHz ± 2 %	
Protection	La sortie est exempte de courts-circuits.	

1.2.9. Alimentation

Tensions secteur	90 ... 270 V en alternatif ou 100 ... 350 V en continu	En une gamme
Fréquence secteur	46 ... 440 Hz ou continu	
Fusible secteur incorporé	1,6 A action différée	Pour toutes tensions secteur
Consommation	29 W	

1.2.10. Données d'environnement

Les données d'environnement ne s'appliquent que lorsque l'appareil est contrôlé conformément aux processus officiels. Pour plus de détails sur ces processus et les critères de panne, s'adresser à l'organisation Philips locale ou à N.V. Philips' Gloeilampenfabrieken, Test and Measuring Department, Eindhoven, Holland.

Température ambiante	+5 °C ... +40 °C −10 °C ... +55 °C −40 °C ... +70 °C	Gamme nominale d'utilisation Gamme limite de fonctionnement Gamme d'emmagasinage et de transport
Altitude	5 000 m 15 000 m	Fonctionnement A l'arrêt
Humidité	L'appareil répond aux normes IEC 68 Db	
Choc	1000 chocs de 10 g, ½ sinusoïde, durée 6 ms, dans chacune des trois directions	I EC 68 E b
Vibration	30 min. dans chacune des trois directions, 10-150 Hz; 0,7 mm crête-à-crête et 5 g accélération maximale	I EC 68 F
Temps de rétablissement	30 minutes (en fonctionnement normal)	quand l'appareil passe de −10 °C à +20 °C à 60 % d'humidité relative
Perturbation electromagnétique	L'appareil répond aux normes VDE, Störgrad K	

1.2.11. Caractéristiques mécaniques

Dimensions	Longueur 410 mm	Non compris commandes, couvercle et pieds
	Largeur 316 mm	
	Hauteur 154 mm	
Poids	9,7 kg	

1.2.12. Accessoires livrés avec l'appareil

Filtre de contraste
Couvercle frontale avec remplacements pour accessoires
Visière pliante PM 9366
Adaptateur BNC banane PM 9051
Borne CAL - Adaptateur BNC
Notice d'emploi et d'entretien

1.2.13. Accessoires en option

PM 9335	Sonde 1:1, câble 1,5 m
PM 9335L	Sonde 1:1, câble 2,5 m
PM 9350	Sonde 10:1, câble 1,5 m, 11 pF
PM 9350L	Sonde 10:1, câble 2,5 m, 14 pF
PM 8927	Sonde 10:1, câble 1,5 m
PM 8927L	Sonde 10:1, câble 2,5 m
PM 9358	Sonde 100:1, 5,6 kV max. 200 Mohm//2 pF (1,5 m)
PM 9347	Sonde T.V. active, 10:1, 11 pF (1,5 m)
PM 9352	Sonde miniature active 10:1 100 kohm//6 pF (2,5 m)
PM 9353	Sonde FET active 10:1, 100:1 1 Mohm//3,5 pF (1,5 m)
PM 9355	Sonde de courant 12 Hz ... 70 MHz
PM 9346	Alimentation de sonde
PM 8960	Jeu pour montage en rack 19''
PM 8992	Sacoche pour accessoires
PM 9380	Appareil de photographie d'oscillogrammes
PM 8971	Adapteur de caméra pour PM 9380
PM 8910	Filtre Polaroid
PM 8980	Visière longue
PM 8901	Jeu de batteries, 24 V dc et 330 V dc
PM 8991	Chariot

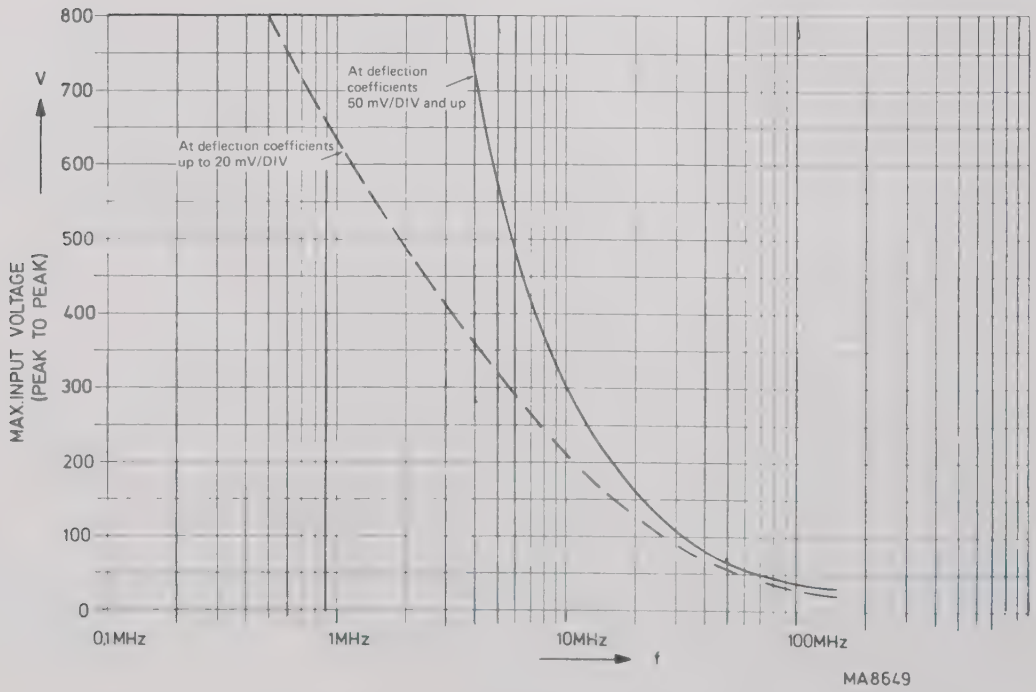

Fig. 1.2. Réduction de la tension d'entrée maximale en fonction de la fréquence

Fig. 2.1. Dépose du couvercle frontal

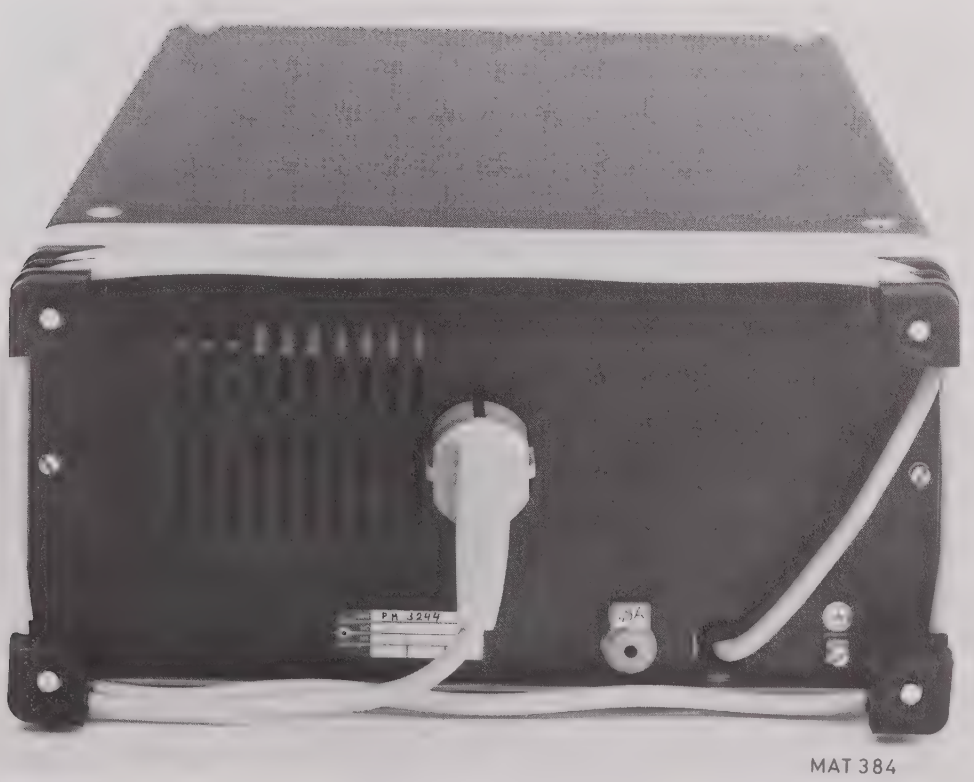

Fig. 2.2. Vue arrière de l'appareil

2. NOTICE d 'EMPLOI

2.1. INSTALLATION

2.1.1. Démontage et montage du couvercle frontal (voir fig. 2.1.)

Démontage:
- Tourner le bouton au centre du couvercle d'un quart de tour vers la gauche (position UNLOCKED).
- Enlever le couvercle.

Montage:
- Tourner le bouton de verrouillage vers position UNLOCKED
- Fixer le couvercle sur la partie avant de l'oscilloscope.
- Enfoncer le bouton et le tourner d'un quart de tour vers la droite (position LOCKED).

Remarque: Pour faire pivoter la poignée, il faut enfoncer les boutons-poussoirs aux étriers.

ATTENTION: Le présent appareil produit des tensions élevées et ne peut donc pas être utilisé avec les plaques du châssis déposées. La fiche secteur doit être enlevée et tous les points haute tension déchargés avant de procéder à n'importe quel travail d'entretien.
Avant de procéder à toute autre connexion, la borne de terre de l'appareil doit être reliée à la ligne de terre du réseau (voir mise à la terre).

2.1.2. Adaption à la tension secteur et fusible

La capacité d'utilisation à toute tension secteur comprise entre 90 et 270 V alternatif ou entre 100 et 350 V continu supprime la nécessité d'adapter le PM 3244 à la tension secteur locale.
La porte-fusible monté sur le panneau arrière porte un fusible à action retardée de 1,6 A (pour toute tension réseau).
S'assurer que des fusibles correctement calibrés et du modèle convenable sont utilisés en cas de remplacement. Il faut éviter d'utiliser des fusibles réparés et de court-circuiter des porte-fusibles. En cas de remplacement d'un fusible l'appareil doit être débranché de toutes sources de tension.

2.1.3. Mise à la terre

Avant toute mise sous tension, l'appareil doit être connecté à la terre de l'une des manières suivantes:
- Par la borne de terre de l'appareil (symbole ⏚).
- Par le cordon secteur à trois conducteurs. La fiche secteur ne doit être introduite que dans une prise possédant un contact de terre. La mise à la terre ne doit pas être éliminée par l'emploi d'un câble prolongateur sans conducteur de terre.

ATTENTION: Toute interruption de la ligne de terre, à l'intérieur ou à l'extérieur de l'appareil ou le débranchement de la borne de terre peuvent rendre l'appareil dangereux. L'interruption intentionnelle est formellement interdite.
Lorsqu'un appareil passe d'un endroit froid à un endroit chaud, la condensation peut provoquer un certain risque. En conséquence, il faut appliquer strictement les prescriptions de mise à la terre.

2.1.4. Démontage

L'ouverture des capots ou la dépose d'organes, à l'exception de ceux directement accessibles à la main sont susceptibles de mettre à jour des composants et des connecteurs sous tension.

L'appareil doit être débranché de toute source de tension avant de procéder à un réglage, un remplacement, une opération d'entretien ou une réparation demandant l'ouverture de l'appareil.

Au cas où le réglage, l'entretien ou la réparation de l'appareil ouvert sous tension sont inévitables, seule une personne qualifiée peut se charger de cette tâche.

Le remplacement d'une fiche secteur se fait aux risques et périls de l'utilisateur. Après le remplacement d'une fiche secteur, un test haute tension conforme à la norme CEI 348 est fortement recommandé.

Ne pas oublier que les condensateurs à l'intérieur de l'appareil peuvent être chargés, même si l'appareil est déconnecté de toute source de tension.

2.1.5. Enclenchement

Le commutateur POWER est incorporé dans la commande d'illumination de graticule ILLUM (panneau avant), juste sous le bord de l'écran.
L'oscilloscope ne doit jamais être enclenché lorsqu'une platine ou un bloc a été enlevé. Ne déposer de platine ou de bloc qu'une minute au moins après la mise hors service de l'oscilloscope.

2.2. BOUTONS, DOUILLES ET LEURS FONCTIONS

2.2.1. Déviation verticale

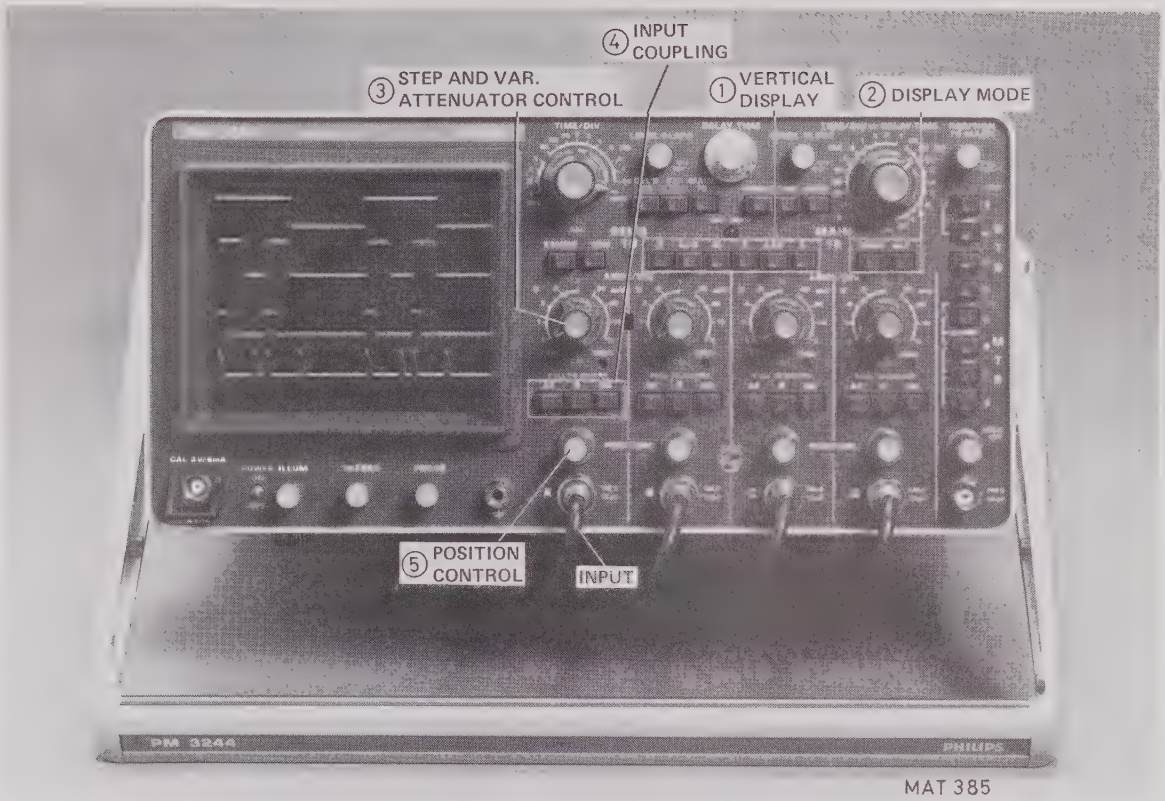

Fig. 2.3. Déviation verticale

1. Sélecteur de déviation verticale

Bouton A	voie A
Boutons A+B	voies A et B additionnés algébriquement
Bouton B	voie B
Bouton C	voie C
Boutons C+D	voies C et D additionnés algébriquement
Bouton D	voie D

Toute combinaison des affichages précités est possible. Si aucun bouton n'est enfoncé, la voie A est enclenchée.

2. CHOP-ALT commutateur

Les affichages mentionnés en peuvent être utilisés en mode découpé ou alterné, en fonction de la position du commutateur CHOP-ALT. Si aucun bouton n'est enfoncé et que deux voies ou plus sont enclenchées, l'affichage est en mode découpé.

3. Commandes d'atténuateur

AMPL/DIV	Commande échelonnée des coefficients de déviation combinée avec:
AMPL/CAL	Commande continûment variable des coefficients de déviation. Si ce bouton est tiré, la polarité de voie est inversée.

4. Commutateur de couplage d'entrée

AC	Couplage de signal par l'intermédiaire d'un condensateur de blocage
0	Entrée de voie connectée à la terre; charge interrompue
DC	Couplage direct

Si aucun bouton n'est enfoncé, AC est obtenu.

5. POSITION — Commande continûment variable indiquant le décadrage vertical de la voie en question.

COMMANDES DE PRE-REGLAGE

BAL	Equilibrage de l'atténuateur par échelons
GAIN	Etalonnage d'amplitude de l'atténuateur par échelons

2.2.2. Déviation horizontale (x)

Fig. 2.4. Déviation horizontale

1. Sélecteur de déviation horizontale

MAIN TB	La déviation horizontale est fournie par le générateur de base de temps principale. Une partie de l'affichage est intensifié lorsque la base de temps retardée est mise en service.
EXT X DEFL	La déviation horizontale est obtenue à partir d'un signal externe provenant: — de la borne d'entrée de l'amplificateur horizontal (3) — d'une des voies de déviation verticale (4) — du réseau (4)
DEL'D TB	La déviation horizontale est fournie par le générateur de base de temps retardée. Si aucun bouton n'est enfoncé, la base de temps principale est enclenchée.

2. Positionnement et agrandisseur de base de temps

POSITION	Commande continûment variable pour décadrage horizontal de l'affichage
TB MAGN	Commutateur push-pull qui augmente le coefficient de déviation horizontale d'un facteur 5. Cet effet est nul en mode EXT X DEFL.

2.2.3. Base de temps principale

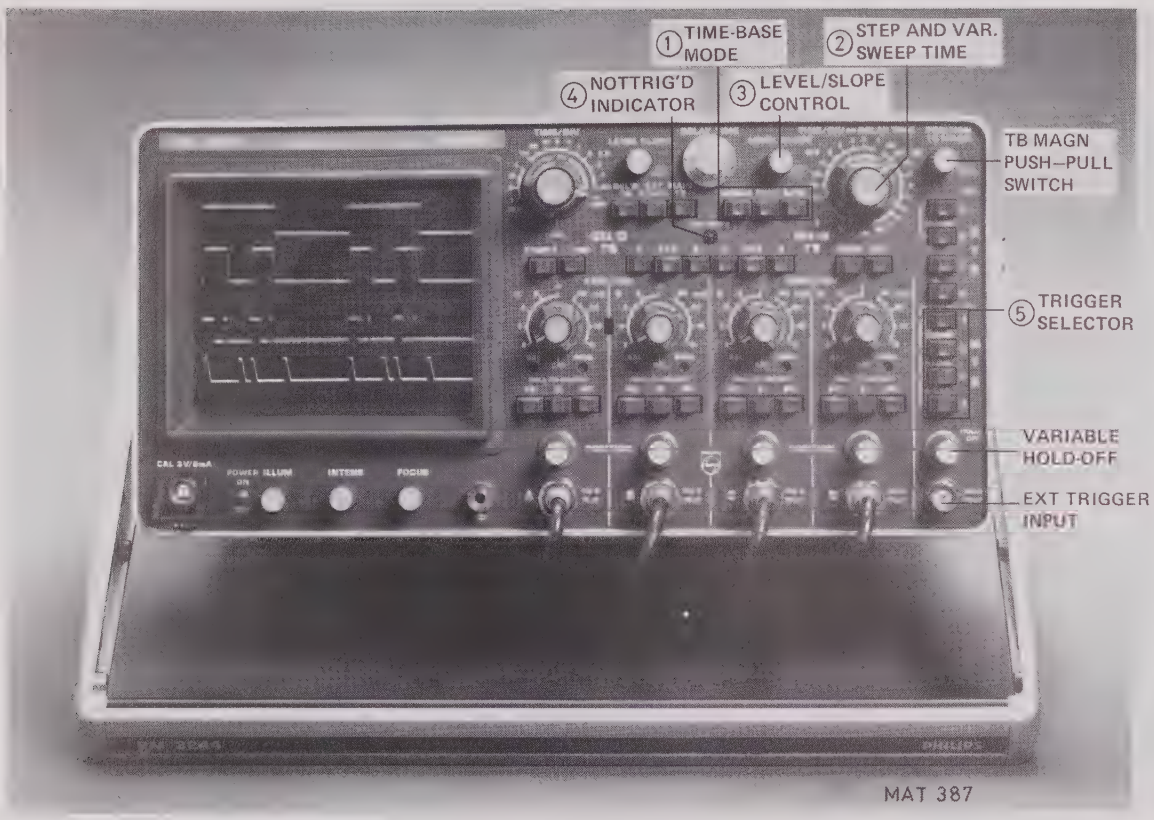

Fig. 2.5. Base de temps principale

1. Sélecteur de base de temps principale

AUTO	Le générateur de base de temps principale est en fonctionnement libre en l'absence de signaux de déclenchement.
TRIG	Le générateur de base de temps est déclenché normalement.
SINGLE	Le générateur de base de temps ne démarre qu'une seule fois à la réception d'une impulsion de déclenchement. Si aucun bouton n'est enfoncé, l'appareil fonctionne en mode SINGLE.

2. Commutateur TIME/DIV or DELAY — Commande par échelons des coefficients de temps pour la base de temps principale; commutateur rotatif à 22 positions. Si la base de temps retardée est en service, le temps de retard, à l'issue duquel la base de temps démarre, est égal au réglage étalonné DELAY TIME x le coefficient TIME/DIV de ce commutateur.

TIME/DIV CAL	Commande continûment variable des coefficients de temps.

3. LEVEL/SLOPE — Commande continûment variable pour sélectionner le niveau de déclenchement auquel le générateur de base de temps démarre. Le commutateur "push-pull" permet de choisir le déclenchement soit sur la pente positive, soit sur la pente négative du signal.

4. Indicateur NOT TRIG'D — S'allume lorsque le générateur de base de temps principale n'est pas déclenché.

5. Sélecteur de source de déclenchement de la base de temps principale — Ce commutateur comporte quatre boutons (A, B, C et D) servant à sélectionner le signal de déclenchement en provenance d'une des voies de déviation verticale. Lorsque les boutons A et B sont enfoncés, le signal de déclenchement composite est sélectionné. Lorsque les boutons B et C sont enfoncés, une partie de la tension réseau sert de signal de déclenchement. Lorsque les boutons C et D sont enfoncés, le signal appliqué au connecteur EXT sert de signal de déclenchement. Si aucun bouton n'est enfoncé, le signal de déclenchement A est disponible.

2.2.4. Base de temps retardée

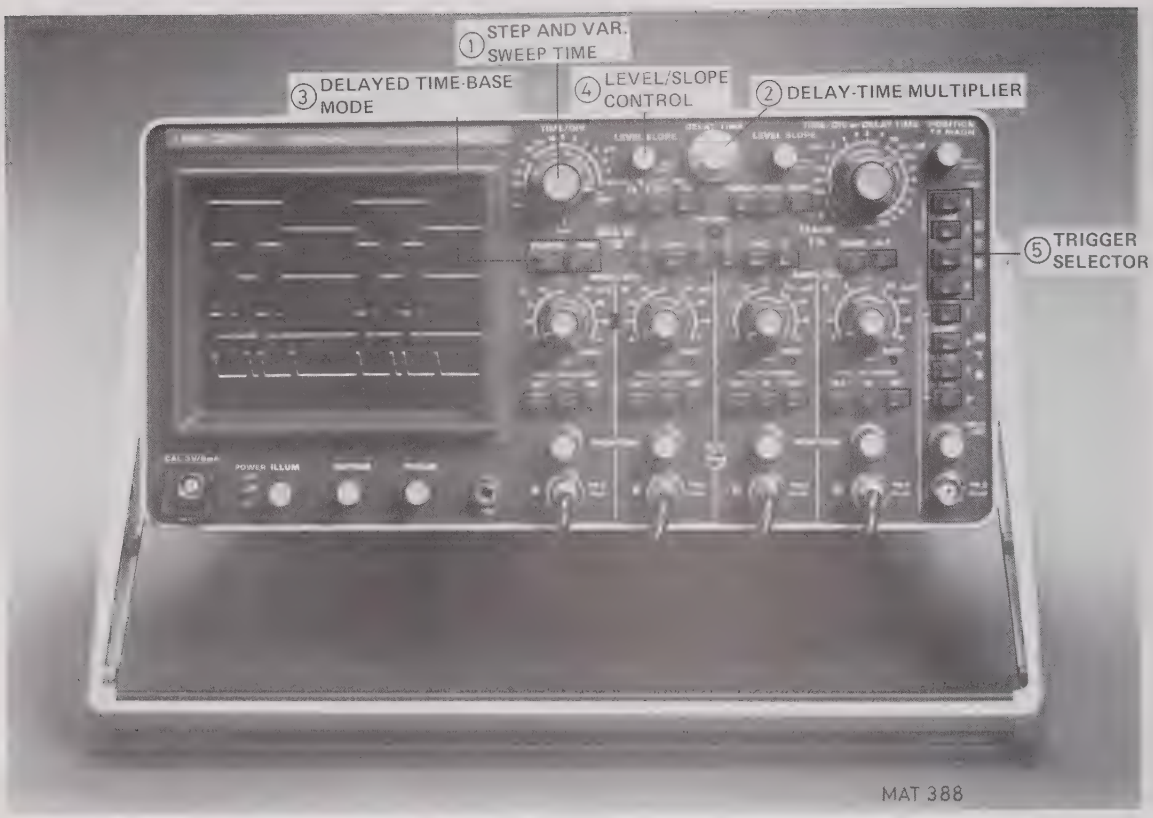

Fig. 2.6. Base de temps retardée

1. Commutateur TIME/DIV	Commande par échelons des coefficients de temps pour la base de temps retardée; commutateur rotatif à 14 positions. Comprend une position OFF, grâce à laquelle le générateur de base de temps retardée est déclenchée.
TIME/DIV CAL	Commande continûment variable des coefficients de la base de temps.
2. DELAY TIME	Potentiomètre étalonné à 10 tours pour ajuster le temps de retard, après quoi la base de temps retardée est mis hors service. Ce temps de retard est égal au réglage DELAY TIME x le coefficient TIME/DIV de la base de temps principale.
3. STARTS/TRIG	Lorsque le bouton STARTS est enfoncé, la base de temps retardée démarre immédiatement après le temps de retard, car elle ne requiert aucun signal de déclenchement. Lorsque le bouton TRIG est enfoncé, la base de temps retardée démarre à la réception d'une impulsion de déclenchement après le temps de retard. Si aucun bouton n'est enfoncé, on obtient le même effet que STARTS enfoncé.
4. LEVEL/SLOPE	Commande continûment variable qui permet de sélectionner le niveau du signal de déclenchement auquel le générateur de base de temps retardée démarre. Cette commande comprend un commutateur push-pull qui permet de démarrer sur le front positif ou négatif du signal de déclenchement.
5. Sélecteur de source de déclenchement de la base de temps retardée	Ce commutateur comporte quatre boutons (A, B, C et D) servant à sélectionner le signal de déclenchement en provenance d'une des voies de déviation verticale. Lorsque les boutons A et B sont enfoncés, le signal de déclenchement composite est sélectionné. Si aucun bouton n'est enfoncé, le signal de déclenchement A est disponible.

2.2.5. Tube à rayons cathodiques

1. POWER/ILLUM	Commande continûment variable de l'illumination de graticule; comprend le commutateur secteur. La lampe témoin indique la position ON.
2. INTENS	Commande continûment variable pour la brillance de la trace.
3. FOCUS	Commande continûment variable pour la focalisation du faisceau.

Divers

1. CAL	Douille de sortie pour étalonnage: — du gain de l'amplificateur de déviation verticale — de la compensation de fréquence des sondes atténuatrices Appropriée pour sondes de tension et de courant.

2.3. REGLAGES PRELIMINAIRES

Avant de procéder à des mesures à l'aide du présent oscilloscope, vérifier si l'équilibrage et l'étalonnage de gain de l'atténuateur par échelons sont adéquatement ajustés pour toutes les voies.
Au besoin, procéder comme suit:

1. Equilibrage continu de l'atténuateur par échelons
   - Enfoncer le bouton MAIN TB du sélecteur de déviation horizontale.
   - Enfoncer le bouton AUTO du sélecteur de base de temps principale.
   - Régler les commandes INTENSITY et FOCUS afin d'obtenir une trace nette et fine.
   - Enfoncer le bouton de voie appropriée du sélecteur de déviation verticale.
   - Enfoncer le bouton 0 du commutateur de couplage d'entrée.
   - Régler le bouton POSITION de telle sorte que la trace se trouve quelque part au centre de l'écran.
   - Mettre la commande continue AMPL sur CAL.
   - Vérifier si la trace ne saute pas lorsque le commutateur AMPL est tourné.
     Au besoin, ajuster la commande BAL.
   - Répéter ce processus pour chaque voie.
2. Etalonnages du gain
   A moins qu'indiqué différemment, les commandes occupent les mêmes positions que pendant le processus décrit ci-avant.
   - Mettre le commutateur AC-0-DC en position AC.
   - Régler la commande AMPL sur .5 V et la commande continue sur CAL.
   - Connecter l'entrée de voie à la sortie CAL.
   - Vérifier si la déviation verticale est de 6 divisions exactement.
     Au besoin, régler la commande GAIN.
   - Une sonde atténuatrice peut également être incluse à cet étalonnage.
     Dans ce cas, il faut tenir compte du facteur d'atténuation de la sonde en fonction de la position du commutateur AMPL.
   - Répéter ce processus pour chaque voie.

Fig. 2.7.

2.4. INSTRUCTIONS DE COMMANDE

2.4.1. Généralités

Avant d'enclencher l'appareil, s'assurer que l'oscilloscope est réglé conformément aux recommandations d'installation (section 2.1.) et que les précautions décrites ont été observées.

2.4.2. Déviation verticale

Pour représenter les voies requises, il faut enfoncer les boutons correspondants du sélecteur de déviation verticale. Si deux traces ou plus sont affichées, l'affichage peut se faire soit en mode découpé, soit en mode alterné.
En mode alterné, les voies sont affichées successivement; pendant le retour du spot de la base de temps principale, l'affichage est commuté d'une voie à l'autre. En mode découpé, les voies sont commutées de l'une à l'autre pendant le balayage de la base de temps.

Le temps d'affichage en mode découpé est d'environ 500 ns. A partir de la version /03: 0,5 ou 2 µs, commutable, voir fig. 3.47

Pour obtenir un affichage constant on utilise généralement le mode alterné à grandes vitesses de balayage et le mode découpé à petites vitesses de balayage.
A remarquer qu'en mode de déclenchement composite, il faut choisir le mode alterné, si non les impulsions de découpage exerceraient une certaine influence sur le circuit de déclenchement.

Les signaux observés sont appliqués aux prises d'entrées A ... D et le commutateur AC/0/DC est réglé soit sur AC soit sur DC en fonction de la composition du signal. Du fait que l'amplificateur vertical est couplé directement, tout la bande passante de l'appareil est disponible et les composantes continues sont affichées comme des décalages de trace en position DC du commutateur AC/0/DC. Ceci peut ne pas convenir lorsque de petits signaux superposés à des tensions continues doivent être représentés. Chaque atténuation du signal résulte en une atténuation de la petite composante alternative.
Le remède à cet état est d'utiliser la position AC du commutateur d'entrée, lequel comprend un condensateur de liaison servant à supprimer les signaux continus et basse fréquence. lorsque des signaux rectangulaires à basse fréquence sont représentés, on obtient une certaine pente de toit.

En position 0 le signal est interrompu et l'entrée de l'amplificateur est mise à la terre, sur cette position, le niveau 0 V est rapidement déterminé.

Les commandes de positionnement permettent de décadrer l'affichage en sens vertical. A remarquer qu'en mode de déclenchement composite le point de démarrage du déclenchement est également influencé par la commande de position verticale.

2.4.3. Déviation horizontale

Selon la position du sélecteur de déviation horizontale, la déviation peut être fournie par:
- la base de temps principale
- une source de signal externe
- la base de temps retardée

La commande de positionnement avec agrandisseur de base de temps permet de décadrer l'affichage en sens horizontal.

Si le bouton MAIN TB or DEL'D TB est enfoncé, la déviation horizontale est déterminée par la base de temps principale ou par la base de temps retardée. Au cas où le botuon EXT X DEFL est enfoncé, la déviation horizontale peut être obtenue à partir:
- d'une des voies de déviation verticale A, B, C ou D
- de la tension réseau (secteur)
- d'une source externe par l'intermédiaire du connecteur EXT.

2.4.4. Base de temps principale

La déviation horizontale linéaire est obtenue lorsque le bouton MAIN TB de l'affichage horizontal commuté est enfoncé.
Le mode de base de temps est choisi à l'aide du sélecteur de base de temps principale.

AUTO — La base de temps fonctionne librement, même si aucune impulsion de déclenchement n'est disponible.
La trace reste visible.
Le mode AUTO peut être choisi dans tous les cas où le mode TRIG est applicable, sauf pour des fréquences inférieures à 10 Hz ou des trains d'impulsions ayant un temps supérieur à 100 ms.
Dès que des impulsions de déclenchement sont disponibles, le fonctionnement libre de la base de temps est automatiquement achevé et le générateur est déclenché normalement.

TRIG — La base de temps est visible lorsque des impulsions de déclenchement sont disponibles et que le niveau de déclenchement est exact.

SINGLE — La base de temps n'effectue qu'un balayage à la réception d'une impulsion de déclenchement. Ensuite, la base de temps doit être remise à zéro en enfonçant à nouveau le bouton SINGLE.
Lorsque des effets uniques sont observés (par exemple par photographie), il faut s'assurer qu'un seul balayage est engendré, même si plusieurs impulsions de déclenchement doivent être produites après le phénomène en question.

2.4.5. Déclenchement

Si un ou plusieurs signaux doivent être affichés, le balayage de la base de temps doit toujours être démarré en un point fixe du signal afin d'obtenir un affichage stationnaire.
A cet effet, le générateur de base de temps est démarré par des impulsions de déclenchement dérivées des sources suivantes, en fonction de la position du sélecteur de source de déclenchement pour base de temps principale:
- une des voies de déviation verticale A, B, C ou D
- un signal composite
- la tension réseau
- une source de tension externe.

Les amplitudes des signaux de déclenchement provenant d'une des voies de déviation verticale ou du signal composite sont proportionnelles à la déviation verticale de l'affichage, car dépendant des réglages de l'atténuateur d'entrée.

Pour le déclenchement composite, les boutons A et B doivent être enfoncés. Dans ce mode, le signal de déclenchement est pris de l'amplificateur de déviation verticale commune, Le déclenchement de signal composite se caractérise par:

a. Le déclenchement par signaux différentiels, par ex. si l'appareil est en mode A+B, l'une des tensions d'entrée étant inversées.
b. Deux à quatre signaux de fréquences différentes et sans rapport, qui peuvent être affichés.
   Dans ce cas, les points de déclenchement des différents signaux doivent se trouver dans la même gamme de niveau de déclenchement.

Remarque: — Lorsque le déclenchement est en mode composite, l'affichage doit toujours se faire en mode alterné. En mode découpé, les impulsions de découpage fonctionnent comme impulsions de déclenchement et l'affichage est instable.
— En mode de déclenchement composite, le point de déclenchement du signal dépend également de la commande POSITION verticale. Pour déclenchement composite en alternatif (AC) une petite modification decrite à la section 3.2.2. (seulement en Anglais) resout ce problème.

Le déclenchement réseau s'effectue en enfonçant les boutons B et C.
Le base de temps principale est déclenchée par une partie de la tension réseau (secteur). Le couplage avec la tension réseau est obtenue par un circuit opto-isolateur incorporé, de sorte que l'appareil reste isolé de la tension réseau.

Le déclenchement externe s'effectue en enfonçant les boutons C et D.
La base de temps principale est alors déclenchée par un signal externe appliqué par l'intermédiaire du connecteur EXT.
La commande LEVEL permet de sélectionner le point de déclenchement sur la pente du signal.
Le commutateur "push-pull" SLOPE permet de sélectionner la pente positive ou négative.

Si le générateur de base de temps principale ne reçoit aucune impulsion de déclenchement, le témoin NOT TRIG'D s'allume. En mode de balayage SINGLE, ce témoin s'allume lorsque le générateur de base de temps a été remis à zéro et est en position d'attente (impulsion de déclenchement suivante).

Le temps de balayage de la base de temps principale est réglé à l'aide du bouton TIME/DIV or DELAY TIME. Si la base de temps retardée est enclenchée, le temps entre le démarrage du balayage de base de temps principale et celui de la base de temps retardée est déterminé par le bouton à 10 tours DELAY TIME (1) et le commutateur du temps de balayage pour la base de temps principale (2): temps = réglage (1) x réglage (2). Le bouton central permet d'ajuster les temps de balayage de la base de temps entre les échelons. Pour les mesures de temps, ce bouton doit toujours être en position CAL.

Le coefficient TIME/DIV de la base de temps peut être accru d'un facteur 5 en tirant le bouton "push-pull" TB MAGN.

La commande HOLD OFF permet de faire varier le temps de blocage du générateur de base de temps principale. Il s'agit du temps dont le générateur a besoin pour être prêt à la réception de l'impulsion de déclenchement suivante. La commande HOLD OFF permet l'affichage constant de signaux plus complexes, comme par exemple les impulsions périodiques doubles.
La position extrême droite est considérée comme la position normale de la commande HOLD OFF. En position extrême gauche, le temps de blocage est étendu.

2.4.6. Base de temps retardée

Si le bouton MAIN TB pour affichage horizontal est enfoncé et que le bouton TIME/DIV de la base de temps retardée n'est pas en position OFF, une partie de la ligne de balayage pour base de temps principale est affichée à intensité accrue.
Le moment de démarrage de la base de temps retardée est déterminé par les réglages du bouton TIME/DIV de la base de temps principale et du bouton à 10 tours DELAY TIME. Si le bouton STARTS du sélecteur de base de temps retardée est enfoncé, la base de temps retardée démarre immédiatement après ce temps de retard. Si le bouton TRIG est enfoncé, la base de temps retardée est démarrée après ce temps de retard et à la réception d'une impulsion de déclenchement.

Le sélecteur de déclenchement de la base de temps retardée présente les mêmes possibilités que le sélecteur de la base de temps principale sauf pour le déclenchement secteur et externe.
La commande LEVEL/SLOPE a la même fonction que décrite pour la base de temps principale.

Le temps de balayage de la partie intensifiée du balayage de base de temps principale dépend de la position du bouton TIME/DIV de la base de temps retardée.
Le bouton central permet d'ajuster le temps de balayage entre les échelons. Pour les mesures de temps, ce bouton doit toujours être en position CAL.

Si le bouton DEL'D TB du sélecteur de déviation horizontale est enfoncé, la partie intensifiée du balayage de base de temps principale est représentée sur l'écran tout entier.

Service data

3. Service data

3.1. DESCRIPTION OF THE BLOCK DIAGRAM (Fig. 3.1)

3.1.1. General information

The PM 3244 oscilloscope comprises the following parts:
- a four channel vertical deflection system
- a channel selection logic
- a main time base
- a delayed time base
- a trigger source selector
- an X amplifier
- a Z-amplifier and c.r.t. circuit
- a stabilized power supply

3.1.2. Four channel vertical deflection system

The four vertical channels A, B, C and D are complete identical. They all have a facility for signal inversion.
The input of each channel is fed via a three-position coupling switch AC/0/DC to the input attenuator.
In the AC position a capacitor is switched in series with the signal path.

In the 0 position the input signal path is interrupted and attenuator input is earthed.

The input attenuator, controlled by the AMPL switch via reed relays, enables the adjustment of the vertical deflection sensitivity in calibrated steps. This attenuator consists of a high and low impedance part separated by a low-drift impedance converter. The d.c. balance of the entire channel is set by a BAL potentiometer which compensates for the d.c. offset voltage of the impedance converter.

The output signal of the attenuator is, via a 50-Ω-coaxial cable, applied to a pre-amplifier stage in the intermediate amplifier where it is transformed into a push-pull current signal. The GAIN control varies the emitter current of the following stage, which is direct-coupled to a cascode voltage amplifying stage. This cascode amplifier provides the following functions:

- shift for the Y trace by means of the POSITION controls
- electronic switching of the selected channel modes
- phase inversion by means of the PULL TO INVERT switches

A trigger signal from each preamplifier stage is fed to the trigger source selector.
The channel selector enables or inhibits the Y-signals as dictated by the channel selection logic.

3.1.3. Channel selection logic

In the ALT mode the channel selection logic is controlled by pulses derived from the sweep-gating multivibrator of the main time base generator.
In this way, the complete trace of every selected channel is alternately displayed on the c.r.t. screen.

In CHOP mode the channel control pulses are derived from an oscillator running at one of the two fixed frequencies (selected with SK201).
These pulses cause an electronic switch in the channel selector which selects on the chopper frequency portions of the selected channels repititively.
The channel selection logic is operated by six independent push-buttons which enable the selection of the display modes:
Channel A, channel B, channel C, channel D, channel A+B and channel C+D added.

A common output of the four channels is connected with the delay line which delays the vertical signals sufficiently to permit the steep leading edges of fast signals to be displayed. A delay-line correction circuit compensates for the distortion introduced by the delay line. A final stage feeds the Y signals to the vertical deflection plates of the c.r.t.

3.1.4. Main time base

The main time base can be triggered on:
- channel A, B, C or D
- A and B composite
- line frequency (push-buttons B and C depressed)
- external (push-buttons C and D depressed)

These trigger sources can be selected with four push-buttons.

From the selector stage, the signal is fed to either the X preamplifier for horizontal deflection (when external X signal is employed), or the trigger amplifier for starting the time-base generator. The input of the trigger differential amplifier stage is connected with the trigger source selector.
The trigger LEVEL adjustment and SLOPE selection switch are also incorporated in this stage. The SLOPE selector switches the differential amplifier to invert the polarity of the trigger signal to enable triggering of the input signals on either positive- or negative-going slopes.

The output of the trigger amplifier is applied to the trigger multivibrator, which produces well-defined trigger pulses. These trigger pulses are used to switch the sweep-gating multivibrator and, when the AUTO pushbutton has been selected, for driving the automatic circuit.

The sweep-gating multivibrator controls the starting and stopping of the integrator circuit that produces the sawtooth waveform required for the horizontal deflection. The integrator circuit consists of charging capacitors switched by transistors, and the resistors selected by the TIME/DIV switch to set the time coefficients in calibrated steps. Continuous control of these time coefficients is obtained by varying the charging current of the time-determining capacitors by means of the TIME/DIV potentiometer.

The hold-off circuit prevents the sweep gating multivibrator from responding to trigger pulses before the time-base capacitor has completely discharged. The hold-off time can be varied by means of potentiometer VARIABLE HOLD OFF. This facility enables suppression of trigger pulses within the hold-off time.

The resulting sawtooth signal of the integrator is fed to the X deflection selector, the hold-off multivibrator and the comparator which is part of the delayed time-base unit. The hold-off multivibrator resets the sweep-gating multivibrator and inhibits its input during the flyback period of the sawtooth waveform. The hold-off circuit also incorporates the single-sweep circuit which causes the main time-base to produce a single sawtooth waveform after the SINGLE pushbutton has been depressed and on receipt of a trigger pulse.

The automatic free-run circuit or auto-circuit makes the time-base free-running when no trigger pulses are applied.

3.1.5. Delayed time base

In principle, the delayed trigger unit and time-base generator use similar circuits to those of the main trigger-unit and time-base generator. The delayed time-base always operates in the single-shot mode. The sweep is initiated by the main time-base generator which also serves as hold-off circuit for the delayed time-base.

The DELAY TIME control in conjunction with the comparator and reset multivibrator determine the delay time for the delayed time-base generator. The delayed time-base is operative unless its TIME/DIV switch is in the OFF position. It starts immediately after the delay time, or upon receipt of the first trigger pulse after the delay time.
This can be selected with the pushbuttons STARTS and TRIG.
When pushbutton MAIN TB of the horizontal deflection mode controls is selected, the part of the trace coinciding with the delayed sweep is intensified.
The delay time calibration unit enables adjustment of the DELAY TIME control range.

3.1.6. Trigger source selector

The TRIGGER SOURCE SELECTOR enables the choice of the following MTB trigger sources: channel A, B, C and D, the composite trigger amplifier, and external input.
For the DTB the following sources can be selected: channel A, B, C and D and the composite trigger amplifier. The trigger signal is DC-coupled.

3.1.7. X-Amplifier

The X deflection selector couples the external X deflection signal from the X preamplifier, the output of the main time-base generator or the output of the delayed time-base generator to the X amplifier and from there to the horizontal deflection plates. The X amplifier comprises the horizontal trace positioning and 5x magnification controls.

The blanking pulse selector supplies blanking pulses to the Z amplifier. These pulses blank the trace at the end of the sweep of the main time-base and provide the extra bright-up pulse if the oscilloscope operates with a portion of the trace intensified. The blanking pulses during the switching of the traces in the chopped mode go direct from the channel selector logic to the Z amplifier.

3.1.8. Z-amplifier and c.r.t. circuit

The Z amplifier receives two input signals. One originates in the time-base generator and is, via the switching circuit, applied to the Z amplifier to blank the trace during flyback. The other one is supplied by the channel selector logic to blank the trace during switching from channel to channel in chopped mode.

The INTENS potentiometer determines the amount of input current fed to the Z amplifier. At the output of the amplifier, the signal is split into two parts: an l.f. + d.c. part and an h.f. part. The h.f. part is fed direct to the Wehnelt cylinder of the c.r.t. The l.f. + d.c. part is modulated on to an oscillator signal and afterwards detected in a peak-to-peak detector. Both signal parts are combined again on the Wehnelt cylinder.
The c.r.t. circuits comprise the FOCUS control and preset potentiometers for trace rotation, astigmatism and distortion.

The high voltage for the post-acceleration anode of the c.r.t. is supplied by a stabilised oscillator whose output voltage is rectified and multiplied by a factor of 5.

The calibrator, an integral part of the oscilloscope, is a square-wave generator which supplies an accurate voltage and current for calibration purposes.
The graticule illumination lamps receive current from the illumination circuit. The amount of supplied current depends on the position of the ILLUM potentiometer.

3.1.9. Stabilized power supply

The mains voltage is full-wave rectified and fed to a voltage regulator. The voltage regulator contains a current sensor which controls in such a way that the output voltages of the power supply stay within specified limits. The rectified mains voltage controls a blocking oscillator which generates a voltage at a frequency of approximately 20 kHz. This voltage is applied to the primary winding of a transformer. The secondary voltages of this transformer are full-wave rectified, smoothed and applied to the various circuits.

The MAINS triggering signal is taken direct from the mains and, via an opto-isolator, fed to the trigger circuits at a safe level, completely isolated from the mains.

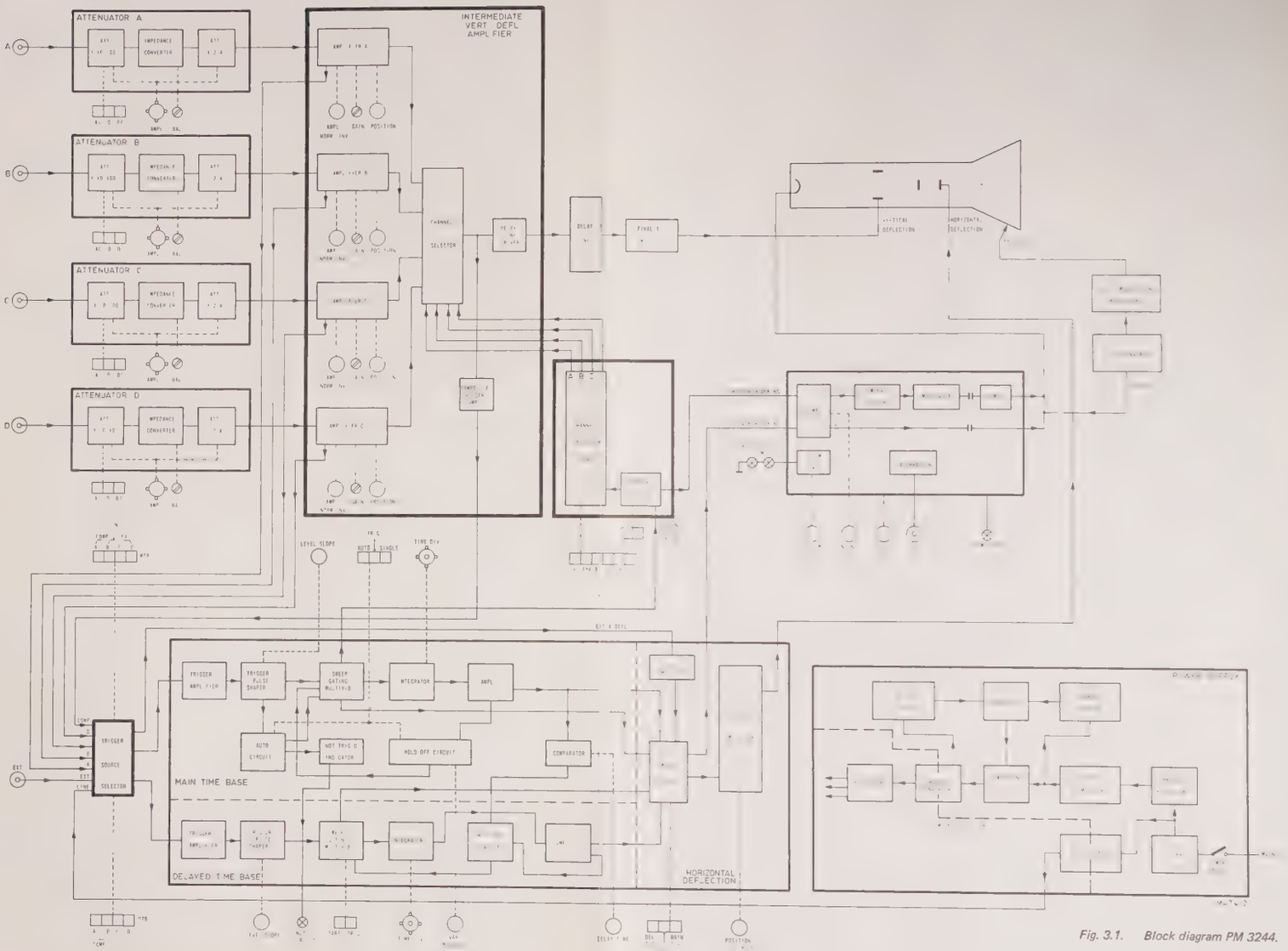

Fig. 3.1. Block diagram PM 3244.

3.2. CIRCUIT DESCRIPTION

3.2.1. Vertical deflection system

3.2.1.1. Input attenuator (fig. 3.17)

As the four input attenuators are completely identical only channel A is described.
The attenuator consists of a triple high-ohmic and a triple low-ohmic voltage divider stage separated by an impedance converter with an a.c. and d.c. path.
The d.c. path is used for drift correction.

The overall attenuation is determined by the combination of the selected sections of both voltage dividers. The various combinations are selected by reed relays that are controlled by the front panel switch SK19.

The high-ohmic voltage divider sections divide 1x, 10x or 100x, each section being switched by 2 reed relays. The low-ohmic voltage divider sections, incorporated in IC 102, divide 1x, 2x or 4x. With the overall combinations of attenuation 9 Y-deflection coefficients are realized from 5 mV/div to 2 V/div in a 1-2-5 sequence.

Constant input capacitance for the various attenuator positions is achieved by the trimmers C107, C102 and C111. In the high-ohmic voltage divider sections the capacitive attenuation for a.c. signals can be adjusted to the resistive attenuation for d.c. signals by means of the trimmers C108, C101 and C109.

The a.c. component of the input signals is fed to the gate of TS101. This gate is protected against excessive negative voltages by means of GR101. The d.c. component developed across R131 is fed to non inverting input 3 of differential amplifier IC101. R129 influences the d.c. voltage on this input and enables adjusting of the 0-DC BALANCE. A part of the impedance converter output signal (on the emitter of TS103) is used as a feedback signal applied to inverting input 2 of the differential amplifier. IC101 compares the voltages on R131 and on the emitter of TS103 and compensates for possible differences. The controls LF GAIN (R132), ATTENUATOR BALANCE (R8) and C122 are incorporated in the feedback circuit. C122 compensates for the stray capacitance in the other input circuit of IC101 and makes 100 kHz SQUARE WAVE ADJUSTMENT possible.

Any d.c. drift in the attenuator circuit, for instance due to temperature changes, is fed to the differential amplifier to provide a correcting d.c. feedback voltage via the output of the differential amplifier (pin 6) to the impedance converter.

The output impedance of the attenuator unit is 50 ohms in all positions, thus presenting a correct impedance match for the coaxial cable link to the succeeding intermediate amplifier. R141 allows compensation of d.c. offset voltages at the output of the attenuator.

Input coupling switch SK22 (pushbuttons AC-0-DC) forms part of the attenuator input stage. When the a.c. position is selected, capacitor C104 is connected in series with the input and reduces the lower frequency limit to 10 Hz. When the d.c. position is selected RE106 is energised and C104 is bypassed via resistors R109 and R111 in series. Selection of the 0 pushbutton de-energises all reed relays, except RE108, in order to block the input signal. RE108 provides an earth path for the impedance converter via R116.

3.2.1.2. Intermediate amplifier (fig. 3.19 and 3.20)

As the four channels of the intermediate amplifier are completely identical, only channel A is described. The intermediate amplifier comprises integrated circuits wherever there is the need for greater stability to safeguard against drift.

The output signal from the channel A attenuator is applied via R406 to point 9 of IC401. This portion of the integrated circuit block consists of a differential amplifier using discrete transistor TS401 in the common-emitter tail circuit as a constant-current source to achieve high rejection. The RC network R408, C402 and C403 constitutes the h.f. response correction filter with C402 as the adjusting element. In this part of the circuit, the overall gain of the channel is adjustable by means of the front-panel preset GAIN control, R9 and the AMPL continuous control, R7, of the Y deflection coefficients. These control the signal current to the emitters of two transistors in common-base mode, which are also part of IC401.

This stage is followed by two discrete pnp transistors, TS402 and TS403, connected in common-base mode, which lower the d.c. potential. The collector outputs are resistor-coupled to the bases of an amplifier forming part of IC402. The emitters of this stage are fed from a constant-current source transistor, TS404. An h.f. correction network is also part of the common-emitter circuit, the adjusting elements of which are R442 and C416.

Each of the four channels has a normal/invert switch, which controls the normal/invert circuit via one wire. In channel A, the normal/invert function is achieved with TS413, TS412, TS411 and TS409. The bases of TS409 and TS413 are held at a fixed voltage level determined by voltage divider R464 and R466.
The bases of the two other transistors are connected to voltage divider R461, R465 and R463. Dependent on the position of SK20A, this divider provides two fixed voltages. In the normal position the potential on the base of TS413 and TS409 exceeds the potential on the base of the other two transistors. The signal is now routed via TS413 and TS409. In the invert position, the potential on the base of TS412 and TS411 is higher and the signal is routed via these transistors and inversion takes place.

Possible unbalance between the normal and invert position can be compensated by the preset potentiometer R448 between the +12 V and earth.

The front-panel POSITION potentiometer, R10 controls the position of the A display by dividing the output from a current-source from TS417 between two transistors, TS414 and TS416. These, in turn, control the direct currents of the transistors in the channel selector, which causes a voltage change over the collector resistors R554 and R561.

The trigger signal is derived from IC401 via transistors TS379 and TS376 which are thermally coupled to reduce drift.
Transistor TS377 is the adjustable current source for this amplifier stage.
The use of this adjustment is the trigger balance between the channels.
The symmetrical amplifier stage of TS379/TS376 is connected to an asymmetrical stage TS378.
The collector of this stage feeds the trigger source selector.
Diode GR401 compensates for changes in the base-emitter voltage of TS378 due to changes of ambient temperature.

The signal for composite triggering is picked off after the channel selector (Fig. 3.20) by means of a symmetrical amplifier stage comprising transistors TS506, TS508, which are thermally coupled to reduce drift, and adjustable current source TS507.
This current source can be adjusted with R531 and compensates the trigger balance.
The amplifier, stage TS506 and TS508, feeds the asymmetrical stage, TS509.

The collector of this transistor feeds the trigger source selector. Diode GR501 compensates for changes in the base emitter voltage of TS509, due to changes of ambient temperature.

A small modification of the composite trigger pick-off amplifier enables AC coupling of the composite triggering. This modification is explained in section 3.2.2.

3.2.2. Modification for AC Coupling of Composite Triggering

The standard trigger bandwidth of the PM 3244 is d.c. ... 50 MHz. When two or more different signals are displayed with composite triggering, the displayed waveforms will partly overlap each other due to the fact that the trigger gap of the signals coincide.

The following modification enables the d.c. component of the composite trigger signal to be blocked with a capacitor. As a result of this, different signals can be displayed on the screen without overlapping each other.
The basic composite trigger circuit and the modified circuit are indicated in Fig. 3.22 and Fig. 3.23.
The lower cut-off frequency of the composite trigger signal depends on the value of the block capacitor.
A low-value capacitor will give bad triggering on low frequencies but good separation on the display.
A capacitor with a higher value will give good composite triggering on lower frequencies but will allow only a small distance between the displayed waveforms on the screen.

The relation between the value of the capacitor and the cut-off frequency is indicated in the following table. The working voltage of this capacitor must be at least 16 V.

C_X	Cross-over frequency comp. trig.
10 μF*	5 Hz
100 nF	500 Hz
10 nF	5 kHz
3.3 nF	15 kHz

* If an electrolytic capacitor is used, connect the "+" of this capacitor to diode GR501.

The circuit to modify, is located on the intermediate amplifier board. Figure 3.23 gives the component layout after the modification.

Required parts:

– Capacitor Cx, refer to table.	
– Preset potentiometer 2.2 kohm linear	5322 101 14008
– Resistor 511 ohm, MR25	5322 116 54525
– Resistor 2,26 kohm, MR25	5322 116 50675
– Resistor 4,42 kohm, MR25	5322 116 50556

Proceed as follows:
Refer to Fig. 3.21 for the basic component lay-out of the intermediate amplifier.
– Remove R529 (10,2 kohm).
– Replace potentiometer R531 (47 kohm) by a 2.2 kohm type.
– Replace R538 (1,27 kohm) by a 511 ohm resistor.
– Unsolder the anode of GR501 from the p.c. board.
Connect the additional capacitor (C_X) between both separated points.
– Connect a 4,42 kohm resistor between the connection C_X/anode of GR501, and the +12 V.
– Connect a 2,26 kohm resistor between the slider contact of R531 and the collector of TS509.
– The adjustment procedure of potentiometer R531 is the same as in the basic circuit. In the EXT X DEFL mode with no input signals, the spot must be in the centre of the screen; refer also to section 3.7.6.4. "Trigger balance adjustment".

3.2.3. Introduction – Channel Selection Logic

The circuit is located on a separate printed-circuit board and is built up with Low-Power Schottky TTL circuits. The block diagram of the logic (Fig. 3.2) indicates that there are four outputs that drive the channel switches in the vertical intermediate amplifiers of the four channels. A channel is switched on if the relevant logic output is "high", and switched off when "low".
In this circuit description "high" is defined as a voltage level between 2 and 5 V; "low", a voltage level between 0 and 0.8 V.

The heart of the channel selection logic is formed by six D-type flip-flops, which are connected in cascade. They are housed in three integrated circuits, type SN74LS74N, indicated IC206, 209 and 214 on the schematic diagram (Fig. 3.24). A brief explanation of their operation is as follows:
Every flip-flop has two outputs: Q (pin 5 or 9) and the inverse of Q (pin 6 or 8). The information applied to the D (= data) input (pin 2 or 12) is transferred to output Q on the positive transition of the clock input (pin 3 or 11). The flip-flop is set in the case where Q is high, and therefore contains a "1". The flip-flop is reset in the case where Q is low, and contains a "0". The clear input (pin 1 or 13) is active when low and makes Q low independently of the clock or D input signal. The preset input is not used and is connected to +5 V.

The row of the six flip-flops represents the six modes: channel A, channel A and B added, channel B, channel C, channel C and D added, channel D. For identification, these flip-flops are marked in the block diagram FFa, FFa+b, FFb, FFc, FFc+d, FFd. All flip-flops receive the same clock-pulses. The flip-flops can be selected with the corresponding display mode switches SK12B ... SK17B. As these switches function independently, any display combination is possible. When one channel is selected, the corresponding flip-flop is continuously set. When more channels are selected, the "1" jumps-on every positive clock transition of the clock inputs, to the next selected flip-flop in the row. From the last selected flip-flop the "1" jumps to the first selected flip-flop in the row. The channel selection logic has provisions to eliminate errors such as an unwanted set or reset of a flip-flop due to interference.

3.2.4. Block Diagram Description – Channel Selection Logic

The flip-flops can be selected with SK12B ... SK17B. Except for SK12B, these switches produce directly in their OFF position a "clear" command to the associated flip-flops so that their inverse output is high. The clear for FFa is given by the block CLEAR CIRCUIT FFa. The six inputs of this block are connected with the display mode switches SK12B ... SK17B.
This block only produces a clear signal for FFa if SK12B is in the OFF position and at least one of the other switches SK13B ... SK17B is in the ON position. This provision activates channel A if none of the display mode switches is depressed.

The six flip-flops are connected in cascade. The D inputs of FF (a+b) ... FFd are connected to the inverse outputs of the preceding flip-flops via five identical blocks SET/RESET FF(a+b) ... SET/RESET FFd. The function of such a block is explained for the block SET/RESET FFc for the two possible situations:
a. The preceeding FFb is not selected (SK14B closed): the signal on the D input of FFb is routed to the D input of FFc.

b. The preceeding FFb is selected (SK14B open): the signal on the D input of FFb is not routed to the D input of FFc. The signal on the D input of FFc now depends on the condition of FFb. If FFb is set, the D input of FFc is high and if FFb is reset the D input of FFc is low.

Because of this provision the "1" jumps-on every positive clock transition, to the next selected flip-flop in the row.

From the last selected flip-flop the "1" jumps to the first selected flip-flop in the row by means of the block SET/RESET FFa. As this block incorporates the elimination of errors facility it is rather complex.

It has twelve inputs that are connected to:
a. The output of FFa
b. The inverse outputs of FF (a+b), FFb, FFc, FF (c+d)
c. SK13B ... SK17B and the inverse of SK13B ... SK16B.

The block generates a high output signal in order to set FFa under the following conditions:
a. At the end of a cycle when the last selected flip-flop in the row will be reset at the next positive clock transition to appear.
b. In the case where a flip-flop is reset by unwanted interference signals: i.e. if a "1" is lost.
c. In the case where more than one flip-flop in the selected row has been set due to interference and the "1" will leave the last selected at the next clock-pulse.

Because of the above-mentioned provisions a potential error has been eliminated when the first selected flip-flop is set at the start of a new cycle.

The inverse outputs of the six flip-flops control the channels via four 2-input Nand gates. These Nand gates are designated CH. A, CH. B, CH. C and CH. D after the channels they control.
When FFa, FFb, FFc or FFd is set, one input of the relevant Nand gate becomes low; so its output becomes high and respectively switches channel A, B, C or D on.
When FF(a+b) or FF(c+d) is set, two Nand gate outputs become high together to achieve the addition of two channels.

The clock inputs of the six flip-flops are connected to the output of the CLOCK PULSE SELECTOR. Depending on the position of the chopped/alternate switch SK18A, this block selects either the output signal of the CHOPPER OSCILLATOR or the output signal of the block ALTERNATE PULSE ON/OFF. Moreover, in the chopped mode, the selector sends the inverted clock-pulses to the input of the BLANKING PULSE SHAPER. This block now generates a positive blanking pulse during the low-to-high transition of the clock inputs of the flip-flops, so that during the switching from one channel to another the display is blanked. The CHOPPER OSCILLATOR produces a square-wave of about 2 MHz if SK201 is open and 0,5 MHz if SK201 is closed. The oscillator is switched off by means of SK18A in the alternate mode. Present from /03 version: older versions have a fixed 2 MHz frequency.

Both the blocks CHOPPER OSCILLATOR and ALTERNATE PULSE ON/OFF can be switched off by the block CLOCK PULSE ON/OFF. The output depends on the inputs as follows:
a. Six inputs are connected to SK12A ... SK17A. As indicated in the block diagram these contacts are operated by the same front-panel push-buttons as SK12B ... SK17B. If more than one channel is selected, more than one input is connected to earth and the output becomes high, so that the clock-pulses are switched on.
b. Four inputs are connected to the outputs of the Nand gates that drive the channel switches in the vertical intermediate amplifiers. If none of the flip-flops is set, no channel is selected and the four inputs are low. If in this situation only 1 channel has been selected, the situation remains unless clock-pulses are applied to the flip-flops in order to set the selected flip-flop.
So if all four inputs are low the clock-pulses are switched on. They are switched off if one input becomes high because the selected flip-flop has been set.

As discussed, the chopper oscillator and alternate pulses are switched off if they are not needed. This is done to limit transmission of interference caused by these signals.

3.2.5. Circuit Description — Channel Selection Logic (Fig. 3.24)

This circuit description explains how the various blocks work and outlines their contents in relation to the schematic diagram.

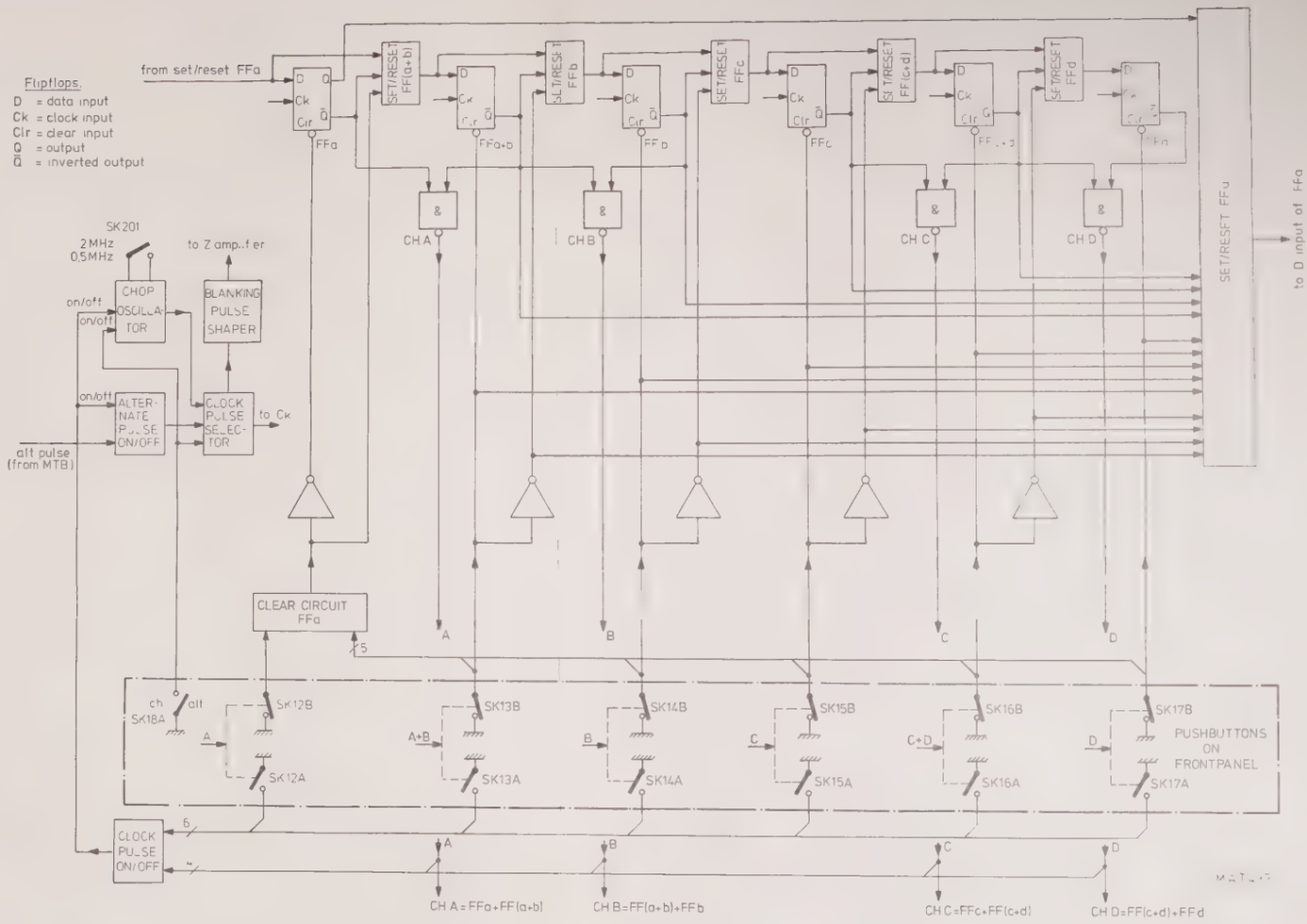

Fig. 3.2. Block diagram, Channel selection logic

Test hint

When troubleshooting it may be easy in some cases to observe the change of voltage levels on certain gates and flip-flops after each clock-pulse. This can be done by using the instrument in alternate and single-shot mode. Every time the single-shot control is operated in clock-pulse is generated at the end of the MTB sweep (MTB triggered by mains unit).

Clear Circuit FFa

The "clear" signal for FFa is made by TS203, Nor gate IC217/8,9,10 and inverter IC203/3.4.
Transistor TS203 has a high collector voltage if the display mode switches SK13B ... SK17B are in the off position so that this transistor does not receive any base current.

SET/RESET FF(a+b) ... SET/RESET FFd: every block contains two Nand gates: as there are five identical blocks, ten Nand gates are needed. These Nand gates are located in the circuit diagram just above the row of six flip-flops. The block SET/RESET FFc, which is built up with the Nand gates IC207/9,10,8 and IC211/4,5,6 operates as follows:

a. With SK14B in the off position (closed) both Nand gates function as an inverter and the voltage level on the D input of FFb is fed through to the D input of FFc.
b. With SK14B in the on position (open) output 8 of IC207 is high. Now IC211/4,5,6 inverts the inverse output of FFb. Consequently, if FFb is set, output 6 of IC211 is high and if FFb is reset, output 6 of IC211 is low.

SET/RESET FFa

The heart of this circuit is formed by five Nand gates of the open collector type with one common collector load resistor R203. These Nand gates form a so-called wired Or, which makes the D input signal for FFa. The Nand gates, which are marked RN (= resistor not), are IC208/1,2,3, IC208/4,5,6, IC208/9,10,8, IC208/12,13,11 and IC213/9,10,8.
The output of this wired-Or is only high if the output of all separate Nand gates are high. One input of each Nand gate is directly controlled by one of the switches SK13B ... SK17B.
The remaining input of IC208/1,2,3 is controlled by the output of FFa. The remaining other four inputs are controlled by two Nand gates each. They are located on the schematic diagram just below the five open collector Nand gates.

The conditions under which the output of the block SET/RESET FFa becomes high, have already been detailed in the block diagram description.

Chopper oscillator

The Nand gates IC202/1,2,3 and IC202/4,5,6 form the chopper oscillator because of the RC feedback circuit with R201, R202, C201, C202 and C200. Capacitor C200 can be connected in parallel with C202 by means of SK201. The oscillator frequency is 2 MHz (SK201 open) or 0,5 MHz (SK201 closed). Described as present from /03 version. Older versions: C200 and SK201 not present:
The oscillator can be switched off by applying a low level to input 2 of IC202 (in alternate mode) or to input 5 of IC202 (in single channel mode).

Alternate pulse ON/OFF

This block is formed by Nand gate IC201/4,5,6. The alternate pulse which is low during the MTB hold-off period is applied to input 4 of IC201. The pulse can be blocked by applying a low level to input 5 of IC201 (in single channel mode).

Clock pulse selector

This block contains three Nand gates IC202/12,13,11, IC201/1,2,3 and IC201/12,13,11.
In the chopped mode, a low level is applied to input 1 of IC201 so that alternate pulses are blocked. Output 11 of IC201 sends chopper pulses to the clock inputs of the flip-flops. In the laternate mode a low level is applied to input 13 of IC202 so that chopper pulses are blocked. Output 11 of IC201 sends alternate pulses to the clock inputs of the flip-flops.

Blanking pulse shaper

Transistor TS202 and matched components form this block.
The transistor normally conducts and its collector voltage is therefore low. Via R204 and C204, TS202 receives a negative pulse on its base during the low-to-high transition of the clock pulse. Now this transistor is non-conductive for a period determined by R204 and C204 and its collector voltage is high. Present from /03 version.

Older versions: pulse shaper contains 2 capacitor coupled amplifier stages. The input of this pulse shaper is connected to output 6 of IC202.

Clock pulse ON/OFF

This circuit is located in the lower left hand corner of the schematic diagram. When two or more channels (SK12A ... SK17A) are selected (switches closed) the base of transistor TS204 is so low that it is blocked. Its collector then becomes high. This collector signal is inverted by means of IC217/11,12,13. Resistors R233 ... R239 are located on the switch unit SK12A ... SK17A (see Fig. 3.50).
The output of this Nand gate is low if two or more channels are switched on, and causes output 8 of Nand gate IC201 to be high. If this output is high clock-pulses are applied to the flip-flops.

Independent of the number of chosen display modes, there is another command which switches the clock-pulses on. This command is made by the Nor gates IC217/5,6,4 and IC217/2,3,1 and the Nand gate IC213/12,13,11. It becomes active if all outputs of the channel selection logic are low (if all flip-flops are reset).
In this case output 11 of IC213 is low, and the clock-pulses are switched on.

3.2.6. Final Y amplifier (fig. 3.27)

The final Y amplifier basically comprises two common-base mode transistors, TS601 and TS602 together with circuit block IC601, followed by circuit block IC602 coupled to output transistors TS606 and TS607.

The delay line output is applied to the emitters of TS601 and TS602 via 50 ohm coaxial cables. The collectors of TS601 and TS602 are resistor-coupled to IC601 (pins 6 and 9). This integrated circuit provides h.f. networks between pins 7 and 8 for correction of frequency distortion inherent in the delay line.

The correction networks comprise capacitors and resistors which constitute variable and fixed filters in the emitter circuit. Transistor TS603 provides a constant-current source for this stage.
Collector supplies are derived from the +12 V rail via the series diodes GR601 and GR602.

The inputs to the final amplifier block IC602 are via pins 6 and 9, the bases of two transistors. The potentiometer, R641, in the common emitter circuits provides a preset gain control to allow for changes in circuit parameters; e.g. if a c.r.t. is replaced. Two additional transistors in the circuit block provide constant-current sources. The outputs of the final amplifier are coupled to the output transistors by diodes GR603 and GR609 which provide d.c. voltage drop. Resistors R649 and R668 supply the normal feed current to the final amplifier from the +45 V rail when there is no signal input.

As the two halves of the output stage are identical, only the output feeding the Y1 deflection plate of the c.r.t. is described. Because of the +6 V feed to the emitter of TS606, the base stands at slightly more than +6 V. Therefore, due to the voltage drop across the series zener diodes GR604 and GR606, the junction of GR603 and GR604 stands at approximately 23 V, being connected via R649 to the +45 V rail. The potential at that junction is maintained at 23 V under signal and no-signal conditions. When the signal applied to pin 6 of the final amplifier demands more current from the 45 V supply, this current is drawn via R656 from the output transistor TS604 to maintain the junction potential of 23 V.

Hence, less current is available for TS606, since transistor TS604 provides constant current. When the signal applied to the final amplifier demands less current, then the current is reversed through R656 to maintain the 23 V potential constant.

In this way, the currents through the output transistors TS606 and TS607 vary in accordance with the signals applied to the bases of the final amplifier. Consequently, the potentials applied to the Y1 and Y2 plates of the c.r.t. are replicas of the signals applied to the Y input sockets.

Coupling capacitor C623 provides a bypass for h.f. signals, to improve the deflection properties at high frequencies.

3.2.7. Trigger source selector (fig. 3.29)

This unit switches the triggering signal from the desired source through to the MTB and DTB trigger amplifiers. These sources are the trigger pick-off amplifiers of the channels A, B, C, D and composite in the intermediate amplifier, the external input amplifier and the mains trigger amplifier. These are selected by SK21 for the MTB and SK10 for the DTB. The signals from the four channels and the composite signal are fed to five identical input circuits. The circuit explanation is given for channel A only.

The current from the pick-off amplifier in channel A is equally divided between the emitters of TS751 and TS752. Resistors R751 and R754 make the current division more independent of the emitter base voltages of TS751 and TS752.

Transistor TS751 is able to pass its collector signal to the base of TS704 if the diodes GR751 and GR753 conduct. These diodes conduct if their cathodes are connected via R753 and SK21 to −12 V. Diode GR752 does not conduct in this situation. The base of TS704 is held at −6 V by means of GR709 and R727. The collector signal of TS704 is applied to the MTB trigger amplifier by means of emitter-follower TS706. The output voltage of this emitter-follower is adjusted to earth potential by means of the adjustable current sources in the pick-off amplifiers.
If the cathodes of GR751 and GR753 are floating because SK21 does not apply R753 to any potential, the collector current flows through GR752 and the triggering signal of channel A does not reach the MTB trigger amplifier.

The circuit comprising TS752 is able to pass its collector signal to the base of TS707 in order to trigger the DTB. This happens if GR754 and GR757 are made conductive by applying their cathodes to −12 V via R757 and SK10. The signal on the collector of TS707 is applied to the DTB trigger amplifier by means of emitter-follower TS708. The output voltage of this transistor is not separately adjustable to earth potential as described for TS706.

The signal on the external input (BU4) is applied to the base of emitter-follower TS701 via a voltage dividing network. This transistor is followed by TS702, which gives base current to TS704 if GR703 and GR704 conduct. These diodes conduct if their cathodes are applied to −12 V by means of R714, R705 and SK21. Resistor R705 permits adjustment of the output voltage of TS706. Diode GR702 conducts if GR703 and GR704 are non-conductive.

The signal from the mains trigger unit on the power supply reaches the base of TS703. The collector signal of this transistor is applied to the base of TS704 if GR707 and GR708 are conducting. These diodes conduct if their cathodes are connected to −12 V via TS705 and R720.
This occurs if TS705 receives base current via R719 and R715, which is connected to earth via SK21. Because of a limitation of SK21, only an earth potential command for mains triggering is available and it is converted by means of TS705 into a −12 V command. Switch SK21 gives −12 V to R773 in the mains trigger mode (SK21B and SK21C both depressed). Diode GR771 becomes conductive in this situation and channel C is not switched on.

The DTB trigger pulses are blocked in the STARTS mode, when they are not needed. This is done by applying −12 V to R735, which is otherwise floating. Moreover, SK10A/2 is now floating; this contact is otherwise connected to −12 V by SK11A/1 via SK11B/3.

The +6 V supply for the trigger source selector is stabilised by means of TS709, GR712 and GR713. The changes in voltage due to variations of ambient temperature of these semiconductors compensate each other. This stabilisation prevents crosstalk of unselected trigger signals via the internal resistance of the power supply.

The signal sources used for triggering of the MTB can also be used for horizontal deflection when push-button EXT.X.DEFL. of switch SK8 is depressed.

3.2.7.1. Trigger amplifier and multivibrator (fig. 3.31)

The m.t.b. trigger signal from the trigger source selector is fed to the base of the emitter follower TS801, which feeds the trigger amplifier.
This is a differential amplifier circuit TS802, TS804, with a constant-current load, TS803, in the common emitter circuit.

The trigger level is set by means of the front-panel control R3, LEVEL, which controls the base of emitter follower TS806. This, in turn, controls the base of one of the differential amplifier transistors, TS804.

The collector loads of the differential amplifier include transistors TS807 and TS808 fed from the +12 V rail. Switching diodes GR802, GR803, GR804 and GR806 form an electronic switching circuit which is operated by the SLOPE switch, SK2.

The SLOPE switch enables triggering on either the positive-going or the negative-going slope of the triggering signal depending upon the position of the switch. In the –ve position, diodes GR802 and GR803 conduct. Hence, the signal at the collector of TS807 is applied to the base of emitter follower TS809. In the +ve position of SK2, diodes GR804 and GR806 conduct and apply the signal at the collector of TS808 to the base of TS809.

Emitter follower TS809 is coupled to the trigger multivibrator TS811, TS812, which switches over in response to the trigger signals. The resulting square-wave pulses from R836 are differentiated by capacitor C856 on the time-base circuit.

The negative-going spikes cause TS851 to conduct and trigger the sweep-gating multivibrator of the main time-base via R871. The positive-going spikes switch TS852 to control the automatic triggering circuit.

3.2.7.2. Auto circuit (fig. 3.31)

Basically, the auto-circuit comprises electrolytic capacitor C858 across the complementary transistors TS853 and TS854. Positive-going trigger pulses at the base of TS854 cause it to start conducting. Likewise, TS853 starts to conduct and capacitor C858 discharges. The output voltage of the auto-circuit is then approximately –10 V. This voltage is applied to the diode GR851 to make it non-conductive. The sweep-gating multivibrator levels are, therefore, such that it is driven by the negative-going trigger pulses received via TS851.

When no trigger pulses are available, TS853 and TS854 are non-conducting and C858 charges. Hence, GR851 conducts and the sweep-gating multivibrator levels are set so that initiation of the sweep is dependent only on the sweep feedback voltage. The main time-base sweep generator is therefore free-running.

3.2.8. Main time base generator (fig. 3.31)

The main time-base generator comprises the sweep-gating multivibrator, TS857, TS858, feeding switching transistors TS869 and TS668, the latter being effectively in parallel with the time-base capacitors of the integrator circuit. Transistor TS871 is used as a current source to charge these capacitors. Selection of the appropriate timing capacitors is by means of the TIME/DIV switch SK6 via switching transistors TS874 and TS876. The sawtooth voltage is developed across the selected time-base capacitor(s) by charging it to a certain level from the constant-current source. The capacitor is then short-circuited very rapidly which results in the characteristic sawtooth waveform.

The sawtooth voltage is fed to the transistors TS881, TS882, in Darlington pair configuration. This stage feeds the sawtooth voltage to the X deflection selector stage and also back to the input of the sweep-gating multivibrator via the hold-off circuit.
The main time-base generator circuit also includes a stage which serves to indicate whether the main time-base generator is triggered or not (GR1).

The various stages of the main time-base generator circuit are now considered in some detail.

3.2.8.1. Sweep-gating multivibrator

Sweep-gating multivibrator TS857 and TS858 is controlled by the following signals:
- the negative-going trigger spikes supplied by the main trigger multivibrator via the differentiating circuit,
- the voltage supplied by the hold-off multivibrator,
- the bias voltage supplied by the auto-circuit.

Potentiometer R873 provides a preset control of trigger stability. The collector circuit of TS857 includes TS856 which, as explained in the Y channel selection logic, provides the ALTERNATE control pulses. The output square-wave of the sweep-gating multivibrator is applied to the switching transistors TS868 and TS869.

3.2.8.2. Switching transistors TS868, TS869 and TS870

These 3 transistors are controlled by TS858 in the sweep-gating multivibrator. TS868 takes over the current from the current source TS871 during the MTB hold-off period. TS870 discharges during this time the time-base capacitor. GR855 only conducts during the charging of the time-base capacitor. Because the voltage of the time-base capacitor comes close to the base voltage of current source TS871 at the end of the MTB sweep GR855 must have a low forward voltage. Therefore, this diode is a germanium type. TS869 conducts during the MTB sweep and provides unblanking via R903 and GR1062.

3.2.8.3. Sweep speeds

The sweep speed or time coefficient is determined by the value of the time-base capacitance in circuit, and also by the magnitude of the charging resistor selected.

The time-base capacitors are C866, C867 and C869. Capacitor C866 is always in circuit; the other two capacitors are selected by transistors TS874 and TS876. These operate as electronic switches and are either fully cut-off or fully-conducting. They are switched on by the application of a positive voltage to their bases from the TIME/DIV switch. According to the position of SK6, these transistors switch in the relevant capacitor in parallel with C866. As mentioned, the sweep speed is also dependent upon the magnitude of the constant-current charge supplied by transistor TS871. This current can be adjusted in steps by selecting the emitter resistance of TS871 by means of the TIME/DIV switch SK6. Continuous control of the charging current can be effected by varying the base drive to TS871 with the continuous sweep control, TIME/DIV potentiometer R6. In the CAL position of this potentiometer, switch SK7 closes and the charging current is solely determined by the calibrated emitter resistance.

To compensate for the temperature coefficient of the transistor (2 mV/degC) the base voltage of TS871 is supplied via transistor TS872. This also has the advantage of reducing the load on the TIME/DIV cont. potentiometer.

Electrolytic capacitor C868 suppresses any possible ripple and interference present on the supply voltage rail. This transistor, in turn, has its base controlled by preset R914 when SK6 is in position 1 ÷ 8. This provides a fine adjustment for the timing circuit since C867, 4.7 μF, has ± 10 % tolerance, whereas the other two timing capacitors have a ± 1 % tolerance. In this position, the preset R914 provides an additional measure of control over the base voltage of TS871. In the positions of SK6 when C867 is not in circuit, the diode GR856 is blocked and the preset control R914 is inoperative.

3.2.8.4. Sawtooth take-off circuit

The sawtooth waveform generated by the time-base is applied to the Darlington pair, TS882 and TS881, the emitter output of the latter being coupled to the X deflection selector via GR1058 and GR1057, to the comparator circuit via R937 and to the hold-off circuit of the main time-base via GR857.

3.2.8.5. Hold-off circuit

The hold-off circuit prevents the sweep-gating multivibrator from responding to trigger pulses before the time-base capacitor has fully discharged. The sawtooth output from the Darlington pair is applied via diode GR857 to the base of emitter follower TS879.
Switching transistors TS877 and TS878 select the appropriate hold-off capacitor, according to the position of SK6, in a similar manner to that described for the main time-base integrator timing capacitors.
Capacitor C862 is always in circuit irrespective of the TIME/DIV switch position.

Charging current for the hold-off capacitors flows via transistor TS879. When TS879 cuts off, the discharge current flows through the circuit with R925 and variable hold-off control R11. R11 allows adjusting of the desired hold-off time and is calibrated in its minimum resistance position. The voltage across the selected hold-off capacitors drives the Schmitt trigger, TS864, TS866, the hold-off multivibrator. The output signal from the hold-off multivibrator is applied to emitter follower TS863 which, in turn, feeds the input of the sweep-gating multivibrator. The emitter-follower TS863 buffers the hold-off multivibrator from the triggering spikes of the trigger pulse-shaping circuits.

Switch SK9 in the base circuit of TS867 is normally open when AUTO and TRIG of the trigger-mode push-button switch are selected. However, when SINGLE mode is selected, SK9 provides via R896 and C864 (mounted on SK9) an earth to the base circuit of TS867 to reset the hold-off multivibrator. Furthermore, since AUTO is not selected, TS879 is cut off via R927 and SK9; consequently, the hold-off multivibrator is no longer reset by the sweep voltage.

When the oscilloscope is used with an external X deflection signal, the internal time-base generator is switched off by depressing the EXT X DEFL pushbutton of SK8. This feeds a +12 V supply via R892 and GR854 to the base of TS867. This transistor holds the hold-off multivibrator so that its output prevents the sweep-gating multivibrator from responding to trigger pulses.

3.2.8.6. "NOT TRIG'D" indicator

Light-emitting diode GR1 in the collector circuit of transistor TS861 serves two purposes:

- it provides a front-panel indication when the time-base generator is not triggered in the AUTO and TRIG modes; i.e., it indicates the absence of trigger pulses. In this condition, TS853 and TS854 are switched off and electrolytic capacitor C858 in the auto-circuit of the main trigger circuit charges. Consequently, the emitter of TS859 becomes less negative and the transistor cuts off. The earth applied via R882 switches on TS861 and the NOT TRIG'D diode, GR1, lights. On receipt of trigger pulses, C858 is discharged, TS859 conducts and cuts off TS861, thus extinguishing GR1, the current being taken over by TS862.
- in the SINGLE mode, the NOT TRIG'D lamp also serves as a reset indicator. On selection of the SINGLE pushbutton, the lamp remains on until the sweep is initiated by a trigger pulse. In this mode, the trigger pulses drives the base of TS859 dependent on the state of the hold-off multivibrator TS864, TS866.

Note: The instrument also operates in the SINGLE mode if none of the trigger-mode pushbuttons is depressed.

3.2.8.7. Delay-time function

The function of the DELAY TIME potentiometer R2 is to provide an adjustable d.c. voltage for comparison with the sweep voltage of the main time-base generator.

This comparison voltage is then used to start the delayed time-base generator at a pre-determined time during the sweep of the main time-base. The comparator circuit is described in the delayed time-base generator section (3.2.10.3.). The DELAY TIME potentiometer is a 10-turn front-panel control.

3.2.9. Delayed time-base triggering

The trigger unit of the delayed time-base is almost identical to that of the main time-base trigger unit, the circuits of which are described in section 3.2.7. Unlike the main time-base trigger unit, the delayed time-base trigger unit has provision for neither external X deflection, nor triggering from the mains frequency. There is, however, provision for triggering by the main time-base (see section 3.2.10.2).

3.2.10. Delayed time-base generator (fig. 3.31)

As the delayed time-base generator is basically similar to the main time-base generator (section 3.2.8.), only the essential differences are described.

3.2.10.1. Sweep speeds

The delayed time-base integrator circuit is a simplified version of the main time-base generator as there are fewer TIME/DIV ranges. Preset potentiometer R1097 provides a measure of control of the charging current to obtain exactly the same sweep speeds of main time-base and delayed time-base.

3.2.10.2. Hold-off circuit

The sawtooth voltage is coupled via the Darlington pair TS1066, and TS1067, and diode GR1052 to the hold-off multivibrator TS1057 and TS1058. Emitter follower, TS1056 provides the hold-off pulse for the input of the delayed sweep-gating multivibrator, TS1052 and TS1053. Transistor TS1054 is set by means of the comparator output signal direct-coupled to its base. This, in turn, resets the hold-off multivibrator, and thus the sweep-gating multivibrator via TS1056.

The delayed time base starts immediately after the delay time and does not need any trigger signal when push-button STARTS of SK11 is depressed.
This is because SK11A point 5 gives an earth potential to R1071.
When no push-button of SK11 is depressed, R1071 is also on earth potential (STARTS mode).
When TRIG is depressed starts the delayed time base after the delay time only after a trigger signal.
Switch SK11A point 5 gives in this case not any potential to R1071.
In the OFF position of the TIME/DIV switch SK4, the sweep-gating multivibrator is switched so that it no longer responds to either the trigger pulses or the reset pulses of the hold-off multivibrator.
Similarly, when X-EXT deflection mode is selected on SK8 a +12 V supply is supplied on R1122 and this inhibits the delayed sweep-gating multivibrator via diode GR1064.

3.2.10.3. Comparator

Transistors TS883 and TS884, connected as a long-tailed pair with TS886 as current source, form the comparator circuit. In this circuit, the d.c. voltage set by the DELAY TIME potentiometer R2 is compared with the sawtooth voltage generated by the main time-base.
When the amplitude of the sawtooth at the base of TS883 exceeds the set d.c. voltage applied to the base of TS884, the collector voltage of TS883 goes more negative and, via emitter-follower TS1054, resets the hold-off multivibrator and delayed sweep-gating multivibrator as previously described.

3.2.10.4. Delay time calibration unit

The DTB start at the end of the MTB sweep is adjusted by means of R979 which influences the base voltage of emitter follower TS887.
The DTB start at the beginning of the MTB sweep is adjusted by means of R987 which influences the base voltage of the emitter follower TS888. The combinations of the base-emitter voltages and diode voltages of TS887/GR862 and TS888/GR863 compensate for possible changes of the base-emitter voltage of TS881 and TS882 due to changes in ambient temperature.

3.2.11. X Deflection selector and blanking switching circuits (fig. 3.31)

These circuits are part of the main time-base printed-circuit board.

3.2.11.1. X Deflection source selector

Depending on the selected position of SK8 the circuit provides for X deflection by the main time-base signal, the delayed time-base signal or the signal from an external source.

The source selector circuit is described according to the pushbutton mode selected.

MAIN TB — In this position of SK8 the +12 V supply is routed via the contacts and R1118 to the junction of diodes GR1057 and GR1058. These diodes conduct and provide a path for the output sawtooth of the main time-base via R1229 to the X amplifier. With the switch in this position, the diode networks, GR1053, GR1054 and GR1066, GR1067 are blocked. Consequently, signals from the delayed time-base and external X deflection preamplifier are not transmitted.

DEL'D TB — In this position of SK8 the +12 V supply is routed via the switch contact and R1108 to the junction of diodes GR1053 and GR1054. These diodes now conduct and provide a path for the output sawtooth of the delayed time-base via R1229 to the X amplifier. With DEL'D TB selected, the signals from the main time-base and external X preamplifier are blocked by the diode networks.

EXT X DEFL — In this position of SK8 the +12 V supply is routed via R1121 to the junction of diodes GR1066 and GR1067. These diodes now conduct and provide a path for the emitter output of TS1072 of the external X preamplifier. Similarly, the diode networks block the main and delayed time-base signals in this position. Another switch contact of SK8 (X-EXT.) removes an earth from the PULL FOR x5 switch, SK3, as this facility is not available when EXT X DEFL is selected.

3.2.11.2. Blanking pulse switching circuit

The switching transistors for blanking pulses for the main and delayed time-base are TS869 and TS1059 respectively.

These transistors conduct during the sweep period of their respective time-bases; i.e. during the unblanking periode. Diodes GR1063 and GR1062 connect the collectors of these transistors to the Z amplifier via R1312. During blanking these transistors are switched off and a current of 3 mA for complete blanking of the trace is fed to the Z amplifier. This current is injected via R1116 and GR1063 (because TS869 is switched off) and via GR1059, R1117 and GR1062 (because TS1059 is switched off) to the Z amplifier.

During the sweep of the main time-base generator 3 mA flows into the main time-base generator via R903 so there is no current for R1312 and the trace is unblanked. If the delayed time-base TIME/DIV switch is at the OFF position, 3 mA flows into the delayed time-base via R1084, R1112. These currents are derived from the +12 V supply, and the potential developed across R1112 prevents TS1068 from being cut off and cuts off GR1063.

The switching is described in accordance with the signal selected by SK8.

MAIN TB — With the TIME/DIV switch of the delayed time-base in the OFF position, TS1059 is permanently on; therefore, GR1063 is blocked. The current step from 0 to 3 mA is then applied to the Z amplifier, via GR1062 during main time-base blanking.

With the TIME/DIV switch of the delayed time-base operative; i.e., not in the OFF position, then bright-up of the main time-base trace by the delayed time-base occurs after the delay time selected. During the part of the sweep where only the main time-base is running (TS1059 cut off), no current flows to the Z amplifier via GR1062; i.e. trace unblanking.

However, the Z amplifier receives a small current from the delayed time-base via GR1063, dependent on the bias of TS1068 and the setting of R1116. Therefore, the trace is not completely unblanked. Immediately the delayed time-base starts TS1059 conducts and the emitter of TS1068 goes negative. Therefore, both TS1068 and GR1063 are cut off.
The Z amplifier intensifies the entire trace. At the end of the delayed sweep, the small current flows through GR1063 again and the trace is once again completely unblanked. Potentiometer R1115 allows adjustment of the base potential of TS1068, in order to vary the current through R1116 and GR1063 during the time that TS1059 is cut off. Thus, the brightness of the intensified part of the trace can be varied.

Via R1109 this change is also transferred to the INTENS potentiometer R13 (see section 3.2.14.1.).

DEL'D TB — If the delayed time-base is selected, GR1059 and GR1062 are non-conductive since the +12 V supply of GR1059 ceases. The current for TS869 in the main time-base is supplied by GR1061. Transistor TS1068 is switched off by the conduction of diode GR1056 and the 0 to 3 mA bright-up information is fed to the Z amplifier via diode GR1063.

EXT X DEFL — If the EXT X DEFL pushbutton is depressed, the MTB and also the DTB are switched off. Therefore, there is no current through R1312 and the trace is unblanked.

3.2.12. Pre-amplifier for external X deflection (fig. 3.31)

Transistors TS1069, TS1071 and TS1072, located on the main time-base printed-circuit board, form a pre-amplifier circuit for external X deflection signals. The input signal from R731 on the trigger source unit is routed to the base of transistor TS1071. The input signal may be one of the triggering signals; namely, a signal on the EXT input socket BU4, the channels A, B, C or D, channels A and B composite or the signal derived from the mains if SK21 push-buttons B and C are depressed.
(see section 3.2.7.)

When the EXT X DEFL position of SK8 is selected the +12 V supply is routed via GR1065 to the emitter of transistor TS1069. TS1071 and TS1069 form a series-shunt feedback configuration: the gain can be adjusted by means of feedback resistor R1131 and the d.c. output level can be adjusted by means of resistor R1132. This series-shunt feedback configuration is followed by emitter follower TS1072. Since diodes GR1066 and GR1067 are conductive because of the +12 V via R1121, the emitter output signal from TS1072 is passed via R1229 to the X amplifier. In this position, the main and delayed time-base are inhibited from the +12 V supply, routed via GR854 and GR1064 respectively.

3.2.13. X-Amplifier (fig. 3.32)

The X amplifier is part of the time-base printed-circuit board U8. The X amplifier receives the input selected by mode switch SK8. This asymmetrical input voltage is fed to the base of transistor TS1201. Transistor TS1204 provides an anti-phase signal, variable by means of the front panel X POSITION potentiometer R4 to give a symmetrical signal to the next stage.
The potentiometer R4 varies the base bias of TS1204 which unbalances the push-pull amplifier resulting in horizontal trace shift on the c.r.t. screen.

The nominal gain of the amplifier can be increased by a factor of 5 by switching the current-source supply, using transistors TS1202 and TS1203 controlled by the front panel PULL FOR x5 switch, SK3.

Normally, current source TS1203 supplies the emitters of transistors TS1201 and TS1204 via the higher value resistors R1224 and R1222 and the diodes GR1203 and GR1204. However, when the PULL FOR x5 switch is selected, the base of TS1202 becomes less negative by the application of an earth (from SK8) via R1231 and SK3. Consequently, TS1202 conducts and TS1203 switches off. The current source is now via GR1201, GR1202 and the lower value resistors R1211 and R1213, which pass the additional current for the x5 gain increase.

Preset control of the gain is provided in the x1 position by R1223 and in the x5 position by R1209.

The x5 position is inoperative when the EXT X DEFL pushbutton of SK8 is depressed. In this position, the earth is disconnected from the SK8 contact that is coupled to SK3.

The two symmetrical output currents of TS1201 and TS1204 are fed to the final amplifier stages with feedback, for each defl. plate. Since these are identical, only one half is described. Basically, the amplifier comprises a cascode circuit using transistors TS1209, TS1211, with feedback via R1237 and R1242.

The cascode circuit is fed via transistor TS1206 in common-base configuration. Transistor TS1208 provides a constant-current source for the final amplifier stage. Zener diodes, GR1208 and GR1209 maintain the average voltage on the deflection plate X1 of c.r.t. B1 at +15 V. Capacitor C1204 improves the h.f. response and the trimming capacitor C1203 provides phase compensation over the feedback path.

3.2.14. C.R.T. Circuits

3.2.14.1. Z-modulator circuit (fig. 3.36)

Basically, the Z unit comprises an amplifier and a modulator/demodulator circuit for the d.c. and low frequency components of the blanking signal. The latter circuit isolates the Z unit from the high potential (−1600 V) present on the c.r.t. cathode and Wehnelt cylinder.

Input signals to the Z amplifier are received from two sources:
- the blanking pulses from the time-base via R1312.
- the chopper blanking pulses from the channel selection logic via R1313.

As stated in section 3.2.11.2. the blanking current is 3 mA and the unblanking current 0 mA. Transistor TS1302, connected in common-base configuration, feeds the current pulses to the amplifier stage, TS1303, TS1304. Front panel control R13, the INTENS potentiometer, provides an adjustment of trace brilliance by regulating the base bias of TS1301.

The slider of R13 is also coupled to the delayed time-base bright-up circuit via a R1109 to maintain the desired intensity ratio for all settings of R13.

A portion of the input current is drained off via TS1301 depending on the setting of R13, the larger the current drain, the more brilliant the trace. Conversely, the more brilliant the trace, the less the common-base transistor TS1302 conducts.

Since TS1302 is cut-off, GR1301 is also non-conductive and a small current flows through R1307 and prevents TS1303 and TS1304 from bottoming.

The blanking signal is passed by TS1302 to the base of TS1303 via GR1301. The diode GR1302 in the collector circuit of TS1302 clamps the black level of the blanking current fed to the amplifier at 3 mA.

The output of the amplifier stage TS1303, TS1304 is coupled to emitter follower TS1306, the output of which switches between 4 V and 40 V approximately for blanking and unblanking respectively. At this point, the a.c. and d.c. components of the blanking signal are routed along different paths. The high frequency components of the signal are passed via capacitor C1308 to the Wehnelt cylinder of the c.r.t. The d.c. and low frequency components of the signal are passed via the low-pass filter R1325, C1306 and R1323 to the emitter of TS1308. Together with TS1307, TS1308 forms a multivibrator, the frequency of which is approximately 100 kHz.

The oscillator output on the collector of TS1308 is therefore modulated by the Z amplifier, the peak-to-peak value depending on the d.c. and l.f. components fed to the emitter of TS1308. The black level can be adjusted by the preset pot. meter R1327. Capacitor C1309 feeds this modulated signal to a peak-to-peak detector and also serves to isolate the high potential present on the c.r.t. cathode circuit. After demodulation by the detector circuit GR1307, GR1308, C1311, R1333, the d.c. and l.f. components are recombined with the h.f. component via R1334 and routed to the Wehnelt cylinder of the c.r.t. via R1336.

3.2.14.2. Focussing circuit (fig. 3.36)

The voltage for the focussing electrode, GR3 of the c.r.t. is derived from a potential divider network between the −1600 V supply from the H.T. converter and earth. The slider of the front-panel FOCUS potentiometer R14 is direct-coupled to the focussing electrode.

The cathode bias for the c.r.t. is also obtained from this divider network, the voltage drop across the neon tube B1301 providing the necessary voltage between cathode and Wehnelt cylinder G1 for complete blanking.

3.2.14.3. H.T. Converter (fig. 3.38)

The −1600 V supply for the cathode, Wehnelt cylinder and focus electrode, and the +8 kV supply for the post-acceleration anode G8 are derived from the h.t. convertor circuit.

Transistor TS1402 together with transformer T1401 forms an oscillator, operating at a frequency of between 25 kHz and 30 kHz. An a.c. waveform of 1600 V is developed across the secondary winding of the transformer. This voltage is rectified by diode GR1403 and smoothed by the filter network C1406, R1409 and C1407, to provide the −1600 V supply.

Regulation is obtained by rectifying (GR1402/C1402) the collector signal of TS1402. The d.c. potential of approx. 85 V thus obtained is compared with the +45 V supply voltage (R1401-R1402) in TS1401.
If the voltage on the collector of TS1402 tends to drop (i.e. the output voltage decreases), TS1402 will start conducting more current and the output voltage increases.

Overload protection is provided by diode GR1402 which switches off if there is excessive current drain throughout GR1403 to the cathode circuit of the c.r.t. This results in the base of TS1401 going positive which reduces its collector current and switches off the oscillator.

The low-pass filter, L1401, C1401, prevents spurious oscillator pulses being fed back into the +45 V supply line.

3.2.14.4. Calibration unit (fig. 3.36)

The calibration unit comprises a built-in square-wave generator using an operational amplifier with feedback loops. The frequency-determining components are resistor R1371 and capacitor C1318.

Point 3 of the operational amplifier IC1301 is kept equal to the average output voltage by capacitor C1317. In this way, the generator is independent of supply voltage fluctuations. Zener diode GR1316 determines the amplitude of the square-wave output, and potentiometer R1362 allows accurate adjustment of output voltage and current. The calibration unit gives an output of 3 $V_{p\text{-}p}$, 6 mA at a frequency of 2 kHz ± 2 %. The output is protected against continuous short-circuits.

3.2.14.5. Graticule illumination control circuit (fig. 3.36)

This circuit comprises the constant current source TS1309/TS1311 that feeds the graticule illumination lamps LA1 and LA2. TS1317 drains away an amount of current from LA1 and LA2, depending on the position of front panel control R12.

3.2.15. Power Supply (fig. 3.40)

The power supply is designed on the switching regulator principle, thus permitting the PM 3244 oscilloscope to be connected to any a.c. mains voltage between 90 V and 270 V, or any d.c. voltage between 100 V and 350 V, without the need for mains voltage adaptors. All voltage output rails are stabilised and a current-limiting circuit protects against overloads.

The basic circuit functions of the power supply are as follows:
– mains rectifier and ripple elimination circuit
– switching series regulator
– chopper circuit
– error sensing and regulator circuit
– current-limiting circuit
– voltage sensing circuit
– secondary supply voltage circuits.

In principle, the power supply operates as follows. After rectification and elimination of the ripple, the smoothed voltage (between 100 V and 370 V) is fed to the switching series regulator. A pulse width modulated switching transistor and commutating diode supply a filter network which averages the voltage output to a fixed d.c. level. This voltage provides the supply for the chopper. The chopper provides the necessary alternating waveform for the supply transformer. In addition, part of the chopper square-wave output is rectified, compared with a reference voltage and is fed back to control the on-off ratio of the switching transistor.

3.2.15.1. Mains rectifier and ripple eliminator

The mains voltage or an alternative source of supply is applied to the mains filter unit FI1801 via the front panel POWER switch SK23 and fuse VL1.
The output of this filter feeds a second filter consisting of L1800, R1801 and C1804. These filters suppress mains-borne interference to the instrument and also interference from the instrument; e.g. switching transients, to the mains supply.

The mains rectifier GR1801 comprises four diodes in a bridge circuit. The ripple that remains after full-wave rectification is eliminated by the action of transistors TS1801 and TS1802 and their associated components.

The ripple elimination circuit operates as follows. The buffer capacitors C1806 and C1808 are charged to approximately the peak voltage of the mains supply. Assume that the output voltage across capacitor C1808 tends to rise with the instantaneous value of the ripple. Transistor TS1802 then draws less current as its emitter goes more positive. Therefore, less base current is applied to transistor TS1801; consequently, its collector voltage drops and counteracts the tendency for the output voltage to rise. By this means, the d.c. output level coincides with the lower level of the ripple voltage superimposed on the unsmoothed rectified voltage, and the ripple is effectively eliminated.

3.2.15.2. Switching series regulator

Transistor TS1807 is the switching transistor, the base of which is driven by the pulse-width modulated rectangular waveform. The filter network comprises the choke L1803 and the capacitor C1809. A constant current flows through L1803 during the turn-on time of TS1807 via its collector. During the turn-off time, the back e.m.f. of L1803 provides a constant current via the commutating diode GR1804. This action is repeated at a frequency of approximately 20 kHz, the chopper frequency. The output voltage across C1809 is thus dependent upon the turn-on/turn-off ratio of the switching transistor TS1807. Resistor R1800 in serie with capacitor C1809 provides a constant regulation. To facilitate starting, a small base current is fed to transistor TS1807 via resistors R1803, R1804 and R1817.
Note that the value of R1817 depends on the current gain TS1807; refer to chapter "Checking and Adjusting" 3.7.3.1.

3.2.15.3. Chopper circuit

The chopper circuit is formed by the two selected transistors TS1804 together with the base drive transformer T1801, form a push-pull oscillator. The primary windings 3-4-5 of the converter transformer T1802 provide the collector loads for the chopper transistors. Winding 7-8 supplies the feedback winding of the driver transformer. As the driver transformer T1801 saturates easily, a square-wave signal is generated. As soon as the instrument is connected to the supply, the small base current applied to TS1807 via resistors R1803. R1804 and R1817 causes the transistor to turn on. Capacitor C1809 is thus charged by the collector current as described, and its voltage rises. After some time the voltage on GR1806 will be 75 volt and the voltage on trigger device GR1825 approx. 32 volt (the "fire voltage"). Now GR1825 will trigger and has a "breakback voltage" of about 6 volt. This voltage is divided over C1811 and C1812 and the voltage on C1812 becomes so high that one of the transistors TS1804 becomes conductive and the chopper starts. As soon as the chopper starts, the voltage across C1809 drops until TS1807 conducts, controlled by the regulator circuit and the potential across C1809 rises again to ≈95 V. During oscillation, a voltage is developed on the centre tap of the driver transformer T1801 of approximately 1 V negative with respect to the anode of GR1808. This negative potential on the base circuit prevents the conduction of both selected transistors TS1804 due to holestorage capacitance.
Resistor R1800 in series with C1809 prevents parasitic ringing of the circuit.
Resistor R1823 provides for a better start of the power supply in a cold environment.

3.2.15.4. Error sensing and regulator circuit

Regulation of the chopper output is achieved by comparing a portion of its output voltage against a stable reference and feeding the error voltage back via an operational amplifier to control the on/off ratio of the switching transistor. The basic components of the sensing and regulating circuit are primary winding 7-8 of T1802, voltage-regulator integrated circuit IC1801, potentiometer R1834 and transistor TS1809.

The circuit operates as follows. The square-wave voltage of approximately 9 V_{p-p} across winding 7-8 of T1802 is half-wave rectified by GR1812 and produces a d.c. voltage of approximately −8 V with a superimposed ripple of about 250 mV_{p-p} across capacitor C1817. This ripple voltage is the sensing voltage used for comparison, and is fed to the inverting input 2 of the operational amplifier IC1801 via capacitor C1821. Input 2 is also connected to point 4 of the integrated circuit via R1829. An internal stabilising network between points 4 and 5 results in an input voltage at point 2 of approximately −1 V together with the superimposed ripple of 400 mV_{p-p}. The non-inverting input 3 of IC1801 is connected to the wiper of R1834, the potentiometer that samples the output voltage across C1817 via R1836, R1833 and diode GR1813. Diode GR1813 conducts via R1832 because of the potential across C1816. The ripple voltage is eliminated from the non-inverting input 3 by capacitor C1818 which is coupled between the wiper of R1834 and the positive side of C1817. Although the ripple at the inverting input 3 approximates to a sawtooth waveform, because of the high gain of the amplifier, the output on point 6 is a rectangular waveform.

The on/off ratio of this rectangular waveform is dependent upon the amplitude of the ripple compared with the reference voltage. The frequency of the rectangular waveform is synchronous with the chopper frequency. The rectangular waveform on point 6 is applied to the base of TS1809 which, in turn, controls the on/off time of the switching transistor TS1807.

The overall function of the voltage sensing and regulator circuit is best considered by assuming a change in output. Any tendency for the output to increase would produce an increase in voltage across C1817. The voltage on input 2 of IC1801 will go more negative as result. Likewise, the voltage on input 3 will go more negative, but to a lesser extent because of the limiting action of the potentiometer R1834 and its associated circuit. Because of this differential, input 3 will be more positive with respect to input 2. In terms of the output on point 6, this means that the positive part of the rectangular waveform will be of longer duration over the duty-cycle. This signal is inverted by transistor TS1809, which results in transistor TS1807 being blocked for a longer period. Consequently, the output of the switching series regulator decreases and restores circuit equilibrium. Conversely, any tendency for the output to decrease would result in the switching transistor TS1807 being on for a longer period. The output of the switching series regulator would increase to restore circuit equilibrium.

In addition to output sensing, anticipatory control is provided from the mains voltage. Input 3 of IC1801 is also coupled to the rectified mains voltage via resistor R1806. Any variation in mains voltage will be reflected at the input 3 of IC1801. The resulting differential with respect to input 2 will produce a compensating regulating action as described.

3.2.15.5. Current limiting circuit

A current sensor circuit automatically cuts off the series regulator if excessive current is demanded by the circuit. The current-limiting circuit comprises transistor TS1808, trigger device TS1811 and their associated components.

The current supplied by the power unit flows through the series resistor R1819 and the potential drop across this resistor is used to control transistor TS1808. If the supply current becomes excessive, transistor TS1808 starts to conduct. In turn TS1811 fires and pulls the base of TS1812 to −8 V. TS1809 is now continuously conducting by the base current delivered via R1816 (the output of IC1801 does not draw any current as this is an emittor follower output). By the current through TS1809, the switching transistor TS1807 is then continuously blocked. Consequently, the chopper stops operating. However, the small base current fed to TS1807 via resistors R1803, R1804 and R1817 enables C1809 to charge slowly. When the Z-voltage of GR1806 and GR1825 is reached, the chopper restarts and is switched off again immediately if the overload or short-circuit persists. Depending on the mains voltage, this cycle is repeated approximately every second so long as the fault condition persists.

3.2.15.6. Switching-on voltage-sensing circuit

In similar manner to the current limiting circuit, a voltage sensing circuit cuts off the switching series regulator if, for any reason, the output voltage of the power supply is too low for the operational amplifier IC1801 to give satisfactory control. Voltage sensing is performed by transistor TS1812. During initial switch-on of the instrument, if the output across winding 7-8 is too low, TS1812 is cut off because Z-diode GR1835 is not yet conducting. Consequently, the positive potential developed across C1814 is applied via R1816 to the base of TS1809. This transistor conducts and turns off switching transistor TS1807. The circuit prevents damage to the switching transistor, which could occur if it were operated with insufficient base current.

3.2.15.7. Secondary supply voltages

The primary windings of the supply transformer T1802, as previously stated, are the collector load circuits of the chopper transistors. The secondary windings providing the voltages for the various circuits in the instrument are completely isolated from the mains power supply.

The filament of the c.r.t. is supplied by the voltage across secondary winding 17-18, rectified by GR1822 and smoothed by electrolytic capacitor C1827. The winding is a.c. coupled to earth via C1830.
All other supply feeds are derived from tapping points on a single secondary winding, earthed at a single point to the transformer screen to reduce interference. Each supply is individually rectified and smoothed.

3.2.15.8. Mains opto-isolator

The trigger/deflection source derived from the mains supply is completely isolated from dangerous a.c. voltages by an opto-isolator TS1813. This consists of a light-emitting diode and photo-transistor combined in one envelope.
The a.c. mains derived from the mains filters is rectified by diode GR1819 and smoothed by C1823 to provide d.c. current through the light-emitting diode. R1838 and R1840 are connected in series and have such a value that their dissipation stays within the permissible limits when using a d.c. mains voltage of 350 V. GR1815 protects the LED in TS1813 against too high reverse voltages. A portion of the a.c. mains is superimposed on this d.c. current, the magnitude depending on the setting of preset resistor R1841. The output is routed to the trigger-source selector (unit 16) R716 via capacitor C1824 and BU806 of the time base and X-amplifier p.c.b. (unit 8).

3.3. OPTIONAL M.T.B. GATE OUTPUT, D.T.B. GATE OUTPUT AND EXTERNAL Z-MODULATION (Fig. 3.42, 3.43 and 3.44)

3.3.1. General

The circuits for these 3 options can be mounted on a printed circuit board. The unit must be installed according to Fig. 3.43 on the side profile of the instrument beside the Z-unit. The lay-out of this unit after the components have been assembled is indicated in Fig. 3.42.
The necessary 3 BNC sockets can be mounted in any of the 5 holes provided in the rear frame of the instrument.
Only in the rear cover plate 3 holes must be drilled.
Supply voltages: the wires for the necessary +6, +12 and −12 volt supply voltages are directly soldered to Stocko plug BU503 at the bottom side of the power supply unit.

3.3.2. Main time base gate output

The circuit comprises one transistor BC549C, which is driven by one of the transistors of the MTB sweep gating multivibrator. The collector of this BC549C transistor is the M.T.B. gate output. The output voltage level is about +6 volt during the M.T.B. sweep and about 0 volt during the hold-off period.

Installation:

Replace resistor R868 (on the T.B. unit next to the ALT pulse output) by a series circuit consisting of a 5,36 kOhm resistor and a 261 Ohm resistor. From the junction of both series resistors a 1 kOhm resistor and a coaxial 50 Ohm cable lead the signal to the amplifier stage on the additional printed circuit board (see Fig. 3.44). The output of the amplifier stage is connected to the BNC connector at the rear panel via a coaxial 50 Ohm cable.

Required material:

1 resistor	5.36 kOhm/MR25	5322 116 54597
1 resistor	261 Ohm/MR25	5322 116 54502
3 resistors	1 kOhm/MR25	5322 116 54549
1 capacitor	10 nF, cer. plate	4822 122 30043
1 transistor	BC549C	5322 130 44246
1 metre coaxial 50 Ohm cable (per metre)		5322 320 10003
1 BNC connector		5322 267 10004

3.3.3. Delayed time base output

The circuit comprises one transistor BC549C, which is driven by one of the transistors of the D.T.B. sweep gating multivibrator. The collector of this BC549C is the D.T.B. gate output. The output voltage level is about +6 volt during the D.T.B. sweep and 0 volt if the D.T.B. does not run.

Installation:

Replace resistor R1063 (on the T.B. unit next to contact 7 of Stocko plug BU808) by a series circuit consisting of a 5,36 kOhm resistor and 261 Ohm resistor. From the junction of both series resistors a 1 kOhm resistor and a coaxial 50 Ohm cable lead the signal to the amplifier stage on the additional printed circuit board (see Fig. 3.44). The output of the amplifier stage is connected to the BNC connector at the rear panel via a coaxial 50 Ohm cable.

Required material:

The same as used for the M.T.B. gate output.

3.3.4. External Z-modulation input, suitable for logic analysers

The circuit (see Fig. 3.44) comprises 2 transistors, that both function as a emitter follower. The input circuit consists of 2 resistors and 2 capacitors in order to obtain the same input impedance as the vertical channels (1 MOhm/15 pF) and to obtain the right voltage level at which the display is blanked. This voltage level is approx. +4,5 volt, which is suitable for use with logic analysers.
The input circuit feeds the first emitter follower BC549C. The second emitter follower BC559 feeds TS1302 in the Z-amplifier.

Installation:

The BNC connector to be mounted on the rear of the oscilloscope is connected to the input of the Z-modulation circuit via a 50 Ohm coaxial cable. The output of the Z-modulation circuit is connected to the emitter of transistor TS1302 via another 50 Ohm coaxial cable.

Required material:

1 resistor	560 kOhm, CR37	4822 110 53181
1 resistor	680 kOhm, CR37	4822 110 53183
1 resistor	10 MOhm, CR37	4822 110 53214
1 resistor	33,2 kOhm, MR25	5322 116 50482
1 resistor	33,2 Ohm, MR25	5322 116 50527
1 resistor	1 kOhm, MR25	5322 116 54549
1 resistor	750 Ohm, MR25	5322 116 54536
2 capacitors	10 nF, cer. plate	4822 122 30043
1 capacitor	27 pF, cer. plate	4822 122 30045
1 capacitor	33 pF, cer. plate	4822 122 31067
1 transistor	BC549C	5322 130 44246
1 transistor	BC559	5322 130 40963
1 metre coaxial 50 Ohm cable (per metre)		5322 320 10003
1 BNC connector		5322 267 10004

Adjustments:

After completion of the mounting procedure, the spot intensity must be readjusted in accordance with the adjusting procedure as described in section 3.7.4.2.

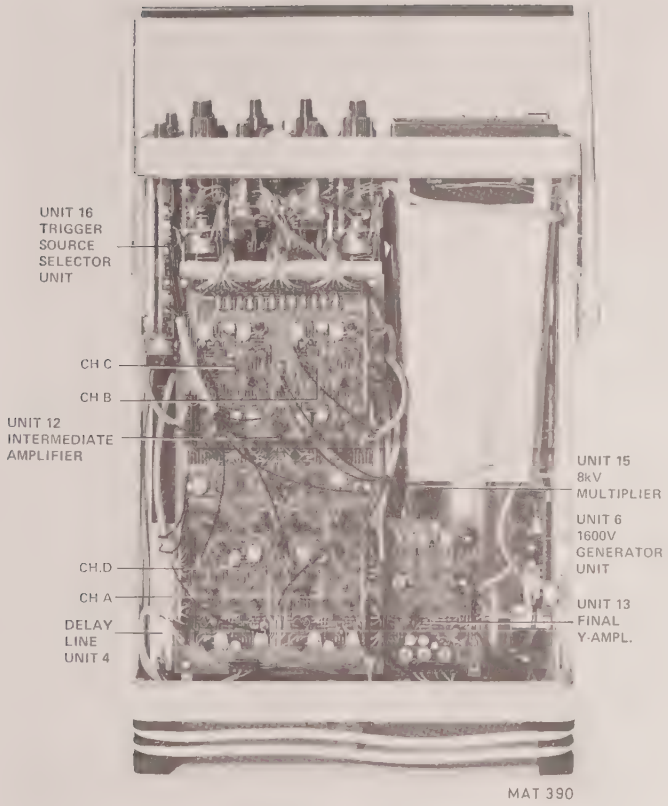

Fig. 3.4. *Unit location, top view*

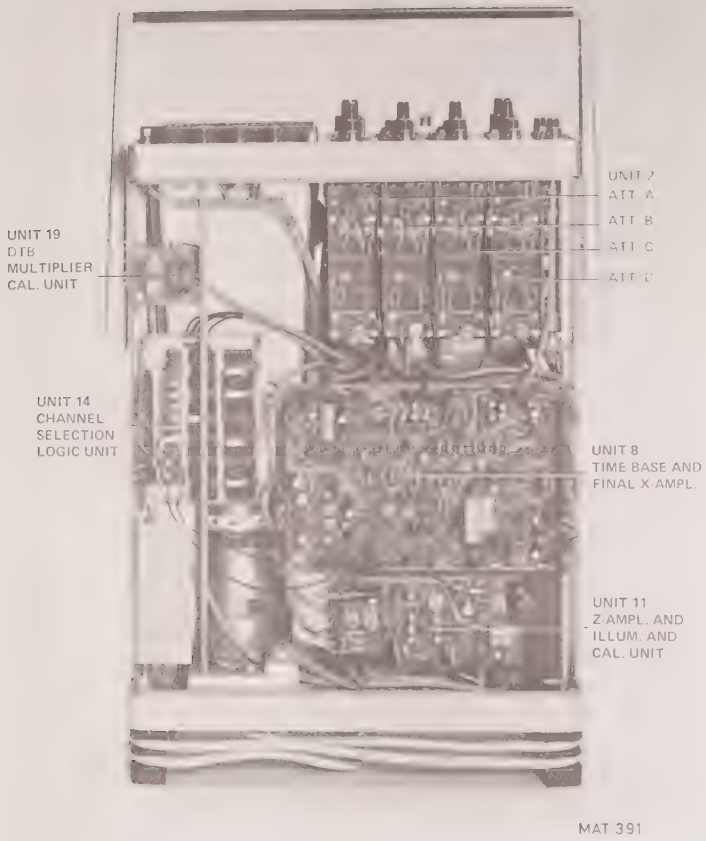

Fig. 3.5. *Unit location, bottom view*

3.4. DISMANTLING THE INSTRUMENT

3.4.1. General information

This section provides the dismantling procedures required for the removal of components during repair and routine maintenance operations. All circuit boards removed from the oscilloscope should be adequately protected against damage, and all normal precautions regarding the use of tools must be observed. During dismantling procedures, a careful note of all leads disconnected must be made so that they may be reconnected to their correct terminals during assembly. For unit-location refer to Fig. 3.4 and 3.5.

Always ensure that the mains supply is disconnected before removing any instrument cover plates.

When removing the E.H.T. cable from the post-acceleration anode of the c.r.t. both the cable connector and the c.r.t. anode contact must be discharged immediately by shorting them to chassis for several seconds with a well-insulated screwdriver.

Damage may result if the instrument is switched on when a circuit board has been removed, or if a circuit board is removed within one minute of switching off the instrument. In Fig. 3.48, 3.49 and 3.50 the cables lay-out between the various units is given.

3.4.2. Instrument cover plates and screen bezel

Both upper and lower cover plates can be removed after the four quick-release fasteners at the corners of each plate have been slackened; do not slacken more than two turns, otherwise the fasteners may come apart.

The screen bezel can be detached by pulling its upper or lower edge.

3.4.3. Removing the knobs

3.4.3.1. Single knobs (fig. 3.3)

- Prise off cap A.
- Slacken screw (or nut) B
- Pull the knob from the spindle.

3.4.3.2. Double knob (fig. 3.3)

- Prise off cap A and slacken screw B.
- Pull the inner knob from the spindle.
- Slacken nut C and pull the outer knob from the spindle.

When fitting a knob or cap, ensure that the spindle is in a position which allows reference lines to be coincident with the markings on the text plate of the oscilloscope.

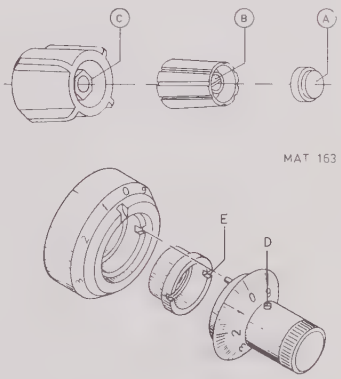

Fig. 3.3. Removing the knobs. MAT 190

3.4.3.3. Delay-time multiplier knob (fig. 3.3)

- Slacken screw D using a hexagonal key and pull the knob from the spindle.
- Remove the nut E and withdraw the ring from the spindle.

When fitting the vernier control, turn the spindle of the potentiometer fully anticlockwise. Place the ring on the spindle so that the reference line corresponds to the zero mark on the calibrated scale. Then lock it with nut E. Fit the inner knob so that its cam is engaged with the slot in the ring. Rotate the inner knob until its zero mark coincides with the reference line on the ring. Secure the assembly by tightening screw D.

3.4.4. Removing the attenuator unit (fig. 3.5)

For cable lay-out see fig. 3.50.

- Remove the appropriate AMPL/DIV knobs as described in section 3.4.3.2.
- Remove the nut under these knobs.
- Remove the appropriate POSITION knob as described in section 3.4.3.1.
- Remove the nut which secure this potentiometer to the front panel.
- Unplug the two multipole connectors and the coaxial plug on the intermediate amplifier from the appropriate attenuator.
- Unsolder the earth connections.
- Remove the two screws that secure the lower part of the attenuator unit to the front panel.
- Carefully lift the attenuator unit out of the oscilloscope.

3.4.5. Removing the time-base and X amplifier circuit board (fig. 3.5)

This unit is the large rectangular printed-circuit board on the underside of the instrument adjacent to the c.r.t.
For cable lay-out see fig. 3.48.
- Unplug the ten multipole connectors.
- Unplug the two coaxial plugs on the board.
- Unsolder two connections to the Z amplifier
- Unsolder two trigger input connections.
- Unplug the X1 and X2 leads from the c.r.t.
- Remove the five screws securing the circuit board to the chassis.

3.4.6. Removing the Z amplifier circuit board (fig. 3.5)

This unit is the small rectangular printed-circuit board located on the underside, and towards the rear of the instrument.
For cable lay-out see fig. 3.48.
- Unplug the six multipole connectors.
- Unplug the two connections to the time-base.
- Unplug the coaxial connector to the channel selection logic.
- Remove the four retaining screws.

3.4.7. Removing the channel selection logic circuit board

This unit is the small rectangular printed-circuit board located on the underside of the instrument, under the c.r.t.
For cable lay-out see fig. 3.48.
- Unplug the coaxial cable on the Z unit and on the time base unit which are connected to the channel selection logic p.c.b.
- Unplug the three multipole connectors.
- Unplug the four coaxial cables on the intermediate amplifier unit which are connected to the channel selection logic p.c.b.
- Remove the two retaining screws.

3.4.8. Removing the intermediate amplifier circuit board (fig. 3.4)

This unit is the large rectangular printed-circuit board located on the upper side of the instrument.
For cable lay-out see fig. 3.50.
- Unplug the twelve coaxial plugs.
- Unplug the twelve multipole connectors.
- Unsolder the two coaxial cables from the delay line.
- Remove the six retaining screws.

3.4.9. Removing the final Y amplifier circuit board (fig. 3.4)

This unit is the small rectangular p.c.b. located on the upper side of the instrument above the gun assembly of the c.r.t.
For cable lay-out see fig. 3.50.
- Unplug the three multipole connectors.
- Unsolder the two coaxial cables from the delay line.
- Unplug the Y1 and Y2 connectors from the c.r.t.
- Remove the three retaining screws.

3.4.10. Removing the trigger source selector circuit board (fig. 3.4)

This unit is situated on the right side of the instrument.
- Remove the knob of the HOLD OFF potentiometer.
- Remove the shaft of this potentiometer by removing the coupling piece (underside of the instrument).
- Unsolder seven leads connected on the p.c.b. on the underside.
- Remove the screw with which the push-button support is mounted on the front plate.
- Remove the screw from the hold off potentiometer support.
- Remove the knob of the POSITION potentiometer (TB MAGN.).
- Remove the shaft of this potentiometer by removing the coupling piece (upper side of the instrument).
- Remove the support of the POSITION potentiometer by removing the two retaining screws.
- Unsolder the six leads and the five coaxial cables from the upper side of the p.c.b.
- Remove the screw and clamping piece with which the push-button support is mounted on the front plate.

3.4.11. Removing the delay line (fig. 3.4)

This unit is located on the upper side of the instrument under the intermediate amplifier p.c.b. (fig. 3.50).
- First remove the intermediate amplifier p.c.b. as described in section 3.4.8.
- Unsolder the four coaxial cables: two on the intermediate amplifier p.c.b. and two on the final Y amplifier p.c.b.
- Remove the retaining screws.

3.4.12. Removing the 1600 V converter circuit board (fig. 3.5)

This unit is located on the lift side of the instrument.
A metal housing gives protection against the high potentials developed in this circuit.
- Remove the metal protective housing.
- Unplug the multipole connector.
- Unsolder the e.h.t. lead and remove the clip.
- Remove the two retaining screws from the rail-mounting.

For reassembly ensure that the protective housing is re-fitted.

3.4.13. Removing the 8 kV multiplier (fig. 3.4)

This is a scaled unit located on the right of the c.r.t. gun (underside of the instrument).
- Discharge the c.r.t. post-acceleration anode and the e.h.t. connector (see section 3.4.1.) after disconnection from the c.r.t.
- Unsolder the coaxial cable from the 1600 V convertor and remove the clip.
- Remove the final Y amplifier p.c.b. as described in section 3.4.9.
- Spring the 8 kV unit retaining clips from the instrument frame (if necessary remove the power supply unit, see section 3.4.15, from the rear to obtain access to the retaining clips).

3.4.14. Removing the cathode ray tube

- Remove all side connections, carefully, to avoid bending the pins.
- Unplug the multipole connector BU1303 on the final Y amplifier.
- Discharge the e.h.t. connector and c.r.t. post-acceleration anode (see section 3.4.1.) after disconnection from the c.r.t.
- Remove the two rear cover plate screws.
- Carefully remove the tube base (pull backwards).
- Slacken the brace round the neck of the c.r.t.
- Slacken the four screws of the front panel clamping buffers (on the under and upper side of the instrument).
- Remove the bezel by pulling its lower edge.
- Carefully withdraw the c.r.t. through the front panel out of instrument.

When fitting a c.r.t., the inside of the rubber sleeve should be sprinkled with industrial talc to facilitate insertion.

3.4.15. Removing the power supply circuit board (fig. 3.41)

This unit is located in a compartment accessible from the rear of the instrument.
- Unscrew the rear cover plate of the instrument.
- Remove the two screws securing the circuit board to the rear panel.
- Unplug the five multipole connectors and the two wires.
- Carefully withdraw the circuit board out of its compartment.

3.4.16. Removing the push-button switches

First remove the top cover plate for access to these switch units. As these switch units and the DELAY TIME multiplier are interconnected by means of several wires, care should be taken when removing these controls to ensure that these interconnections are not damaged.
- Remove the knobs of both LEVEL potentiometers (see section 3.4.3.1).
- Unscrew, with the tool indicated in fig. 3.9, the two nuts behind these knobs.
- Remove the LEVEL potentiometers.
- Remove the DELAY TIME multiplier knob.
- Remove the DELAY TIME potentiometer.
- Remove the switches SK8 and SK9 by unscrewing the two screws and removing the two clamping pieces (see fig. 3.7).

In this situation it is also possible to remove the NOT TRIG'D LED indicator GR1.
- Remove the knobs of the m.t.b. TIME/DIV and d.t.b. TIME/DIV switches as indicated in section 3.4.3.2.
- Remove these switches (unplug the multipole plugs on the time base and X amplifier p.c.b. connected with these switches).
- Remove the switches SK11 ... SK18 by unscrewing four screws and removing four clamping pieces (see fig. 3.7).

To remove a push-button switch, the hexagon screws that secure it to the front panel must be removed. To replace one switch-section of a push-button set, refer to fig. 3.6.

To remove a push-button switch which is mounted on a p.c. board:
- Remove the printed-circuit board for replacing a switch in this unit.
- Straighten the 4 retaining lugs of the relevant switch as shown in fig. 3.6.
- Break the body of the relevant switch by means of a pair of plier and remove the pieces. The soldering pins are then accessible.
- Remove the soldering pins and clean the holes in the printed-wiring board (e.g. with a suction soldering iron).
- Solder the new switch onto the printed-circuit board.
- Band the 4 retaining lugs back to their original positions.

Before a push-button switch is refitted to the front panel, it is advisable to stick the two parts of the clamping device together by means of adhesive tape or non-hardening glue, in order to facilitate replacement, refer to fig. 3.7.

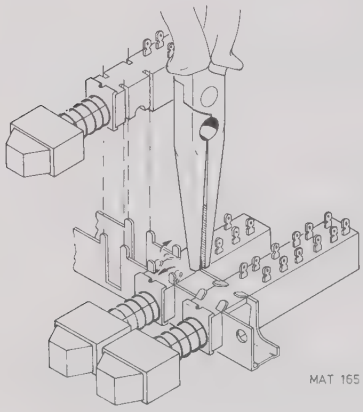

Fig. 3.6. Replacing a switch-segment of a push-button set

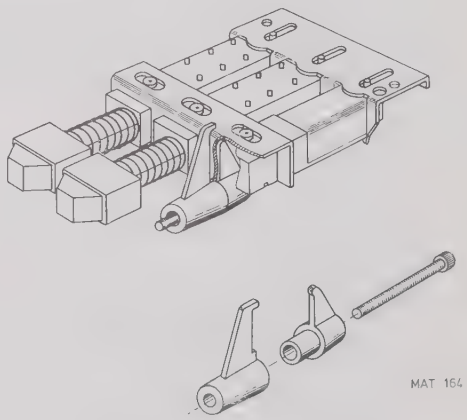

Fig. 3.7. Push-button set clamping device

3.4.17. Removing the carrying handle

- Remove the upper and lower instrument cover plates.
- Remove the plastic strip which is snapped on to the grip by slight leverage under one edge.
- Remove the four hexagon screws which secure the grip to the brackets.
- Depress the push-buttons in the brackets and turn the carrying handle vertically above the upper side of the oscilloscope.
- Keep the push-button of the right-hand bracket depressed and pull the bracket from its bearing.
- Remove the grip from the remaining bracket.
- Depress the push-button of the left-hand bracket and turn the latter vertically below the base of the instrument.
- Keep the push-button depressed and pull the bracket from its bearing.

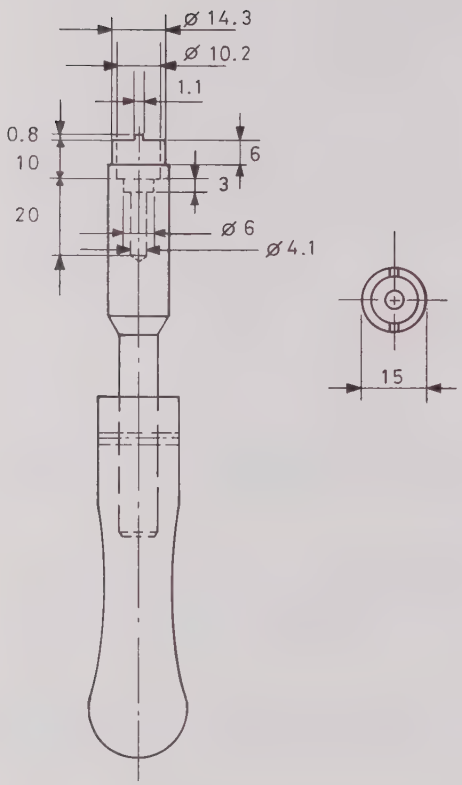

Fig. 3.8. Tool for attenuator switches

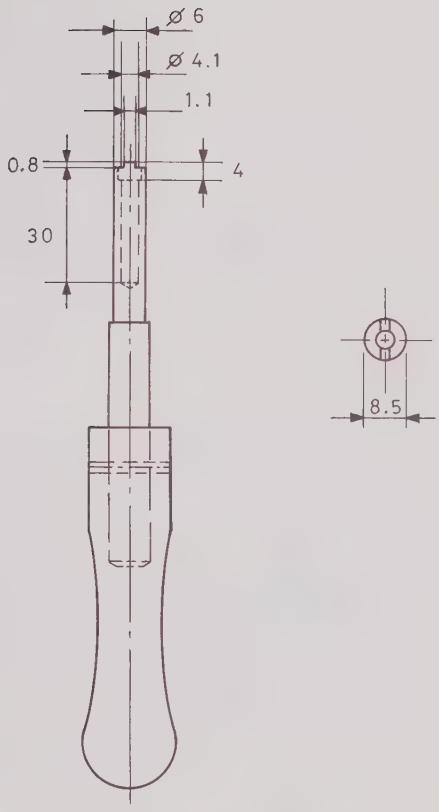

Fig. 3.9. Tool for Position and Level potentiometers

3.4.18. Special tools

Special tool for the slotted nuts of attenuator switches

A tool can be made for this purpose as shown in Fig. 3.8. All dimensions are given in millimetres. The material is silver-steel N094, tempered 40-45 Rc. Service order code 5322 395 54023.

Special tool for the slotted nuts of the POSITION and LEVEL/SLOPE potentiometers

A tool can be made for this purpose as shown in Fig. 3.9. All dimensions are given in millimetres. The material is silver-steel N094, tempered 40-45 Rc. Service order code 5322 395 54024.

3.5. SOLDERING MICRO-MINIATURE SEMI-CONDUCTORS

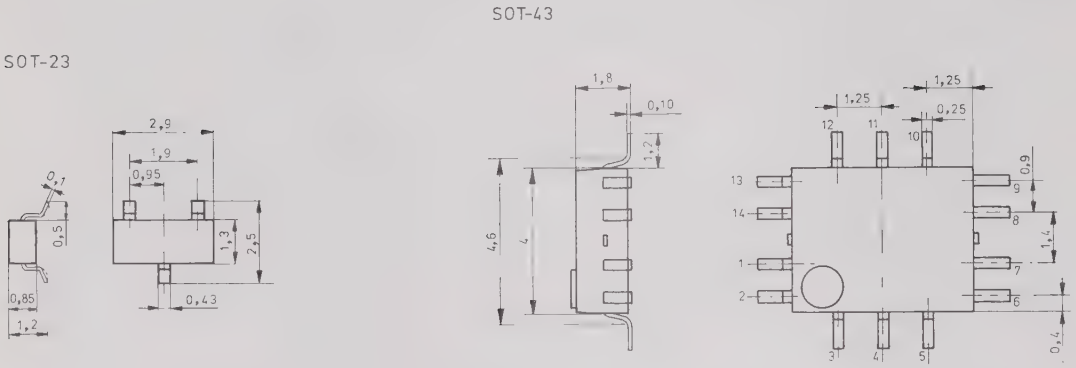

Fig. 3.10. Dimensional drawings SOT-23 and SOT-43

Because of the small dimensions of these SOT semi-conductors and the lack of space between the components on the printed-circuit board, it is necessary to use a miniature soldering iron with a pin-point tip (max. dia 1 mm) to solder a SOT on to a printed-circuit board.

Working method:
- Carefully unsolder one after the other the soldering tags of the semi-conductor.
- Remove all superfluous soldering material. Use a sucking iron or sucking copper litze wire.
- Check that the tags of the replacement part are clean and pre-tinned on the soldering places.
- Locate the replacement semi-conductor exactly on its place, and solder each tag to the relevant printed conductor on the circuit board.

Note: Bear in mind that the maximum permissible soldering time is 10 seconds during which the temperature of the tags must not exceed 250 deg C. The use of a solder with a low melting point is therefore recommended.

Take care not damage the plastic encapsulation of the SOT during the soldering procedure (softening point of the plastic is 150 °C).

ATTENTION: When you are soldering inside the instrument it is essential to use a low-voltage-soldering iron, the tip of which must be earthed to the mass of the oscilloscope.

Suitable soldering irons are:
- ORYX micro-miniature soldering instrument, type 6A, voltage 6 V, in combination with PLATO pin-point tip type 0-569.
- ERSA miniature soldering iron, type minor 040 B, voltage 6 V.
- Low voltage Mini Soldering Iron, Type 800/12 W - 6 V, order no. 4822 395 10004, in combination with 1 mm-pin-point tip, order no. 4822 395 10012.

3.6. TEST AND REPAIR HINTS

3.6.1. General information

- Use an isolating transformer when measurements must be made in the power supply.
- For measuring on the printed-wiring boards, test-pins with sharp points must be used. Be careful not to cause a short-circuit by letting the test-pin slip from the test point.
- Use an appropriate soldering iron and solder with a low melting point, if micro-miniature semi-conductors must be replaced it is essential to earth the tip of the soldering iron to the mass of the oscilloscope.
- Be very careful not to bend the pins on the neck of the c.r.t., since this is likely to result in a gas-leak.
- Do not remove any transistor, when the oscilloscope is switched-on.
- Do not plug and unplug connectors when the instrument is switched on.
- Do not touch any trim potentiometers or trimmers before a fault has been located.
- If internal coaxial cables have been taken loose, take care not to make earth-short-circuit if the connector might slip over the p.c. board.
- If the H.T. plug of the c.r.t. is taken loose, carefully discharge both the H.T. cable and the H.T. connection of the c.r.t. for at least several seconds, to avoid the risk of electrical shocks.

3.6.2. Y-amplifier

If there is a fault in one of the Y channels, it can easily be traced to a certain unit by combining the attenuator of one channel and the intermediate amplifier part of the other channel.
This is simply a matter of plugging coaxial cables.

Be careful if a reed relay in the attenuators must be replaced. Such a relay consists of a glass tube, containing the contact points, and a coil. The coil is fitted around the glass tube, with a piece of foil in between for shielding. Since the glass tube is rather fragile, the connection wire of the relay must be bent and soldered with caution. Do not twists the connection wires, as this may cause broken glass-metal seal and unreliable contact inside the glass-tube.

To locate an instability problem in the Y amplifier, both input- or both output cables of the delay-line may be taken loose. The trace must then be approx. in the middle of the screen.
Check also the c.r.t. side-connection pins on corrosion.

3.6.3. Time-base and X-amplifier

- The easiest way to test the time-base generator (we refer here to the main time-base generator, but a similar procedure applies to the delayed time-base) is to remove transistor TS868, switch in a low sweep speed and short-circuit the collector of TS871 to earth. During the time that this short-circuit is open, the time-base capacitor (869) is charged. The charging process can be traced through the time-base unit, where the changing level must be measured in all circuits.
  A fault is then located at a point which does not follow the changing level.
  The final stage of the X-amplifier can be checked by interconnecting both emittors of TS1206 and TS1207. The displayed dot must then be approx. in the middle of the screen.

3.6.4. Instability

Instability of the display could be caused by bad contacts in the multipole- or the miniature coaxial connectors. If necessary check also the wire clamping in the multipole plugs (good contact of the multipole earth connections of the power supply output is very important).
The inner female contact of the miniature coaxial connectors could be cleaned with a dia 0,75 mm twist drill.

3.6.5. Maintenance

After removal, the cabinet plates may be cleaned with a mild non-abrasive household detergent. Do not use chemical solutions such as trichlorethylene and acetone.
The 3M company has developed a new cleansing pad (White Cleansing Pad, Catalogue No. 8440) which when soaked in water, ethanol or a common household cleansing agent will also penetrate holes and pores. This method is similar to that of abrasive cleaning pads but lacks their abrasive action.
Abrasive cleaning pads should not be used, otherwise surfacescratches will result.

The text plate may be cleaned with the same detergent, with alcohol or with white spirit. Always use a soft cloth or cotton wool.

3.7. CHECKING AND ADJUSTING

Introduction

The following information provides the complete checking and adjusting procedure for the PM 3244 oscilloscope. As various control functions are interdependent, a certain order of adjustment is often necessary. The procedure is, therefore, presented in a sequence which is best suited to this order, cross-reference being made to any circuit which may affect a particular adjustment. Before any adjustment or check, the instrument must attain its normal operating temperature. Under average conditions this will be approximately 30 minutes after switching on.

All controls which are mentioned without item numbers are located on the front panel of the oscilloscope.

3.7.1. Recommended test equipment

Recommended instrument	Specifications	Example of recommended instrument
Square wave generator	100 Hz - 500 kHz Constant amplitude of 50 mV - 10 V Rise time $\leqslant$ 1 nsec Duty cycle 50%	Tektronix PG506
Square wave generator	10 kHz - 500 kHz Constant amplitude of 5 mV - 2 V Rise time $\leqslant$ 200 nsec Duty cycle 50%	Philips PM 5127 or PM 5771
Sine wave generator	10 Hz - 50 MHz Constant amplitude of 100 mV - 15 V	Tektronix SG503
Time marker generator	0.5 sec – 0.05 μsec in 22 calibrated positions in a 1-2-5 sequence	Tektronix TG501
Digital multimeter	Wide voltage, current and resistance ranges	Philips PM 2527
Oscilloscope	100 MHz	Philips PM 3262
Dummy probe	2:1, R = 1 MΩ, C = 15 pF	–
Low capacitance trimming tools		Philips 800NTX

3.7.2. Preliminary control settings

- Set the POWER switch to OFF.
- Connect the instrument to the mains.
- Depress the ALT button of the vertical display mode switch.
- Depress the MAIN TB button of horizontal deflection switch.
- Depress the AUTO button of the trigger mode switch.
- Set the MAIN TIME/DIV switch to .1 ms.
- Set the DEL'D TIME/DIV switch to OFF.
- Set the AMPL switches to .1 V/DIV.
- Depress pushbuttons A of the m.t.b. and d.t.b. trigger source switches.
- Depress pushbutton A of the vertical display mode switches.
- Set the TIME/DIV and AMPL/DIV continuous controls to CAL.
- Set the POSITION potentiometers to their mid-positions.
- Push the TB MAGN switch to 1x.
- Turn the INTENS potentiometer clockwise.

  Controls not mentioned may remain in any position. For subsequent tests, unless otherwise stated, controls should be left in the same position as in the previous check.
- Set the POWER switch to ON.
- Check that the POWER ON lamp lights up.
- Check that the time base line appears on the screen.
- Check the working of the graticule illumination control.

1. *Survey of adjusting elements and auxiliary equipment*

Adjustment	*Adjusting element*	*Adjusting result*	*Recommended instrument and input signals*	*Example of measuring instrument*	*Chapter*	*Figures*
Power Supply						
Current gain of the switching regulator transistor		Remove transistor TS1808 mains voltage 40V voltage across C1809 must be ±56V	Isolated transformer 22Ω (25W) digital multimeter	2422 529 00005 5322 115 50006 PM2517 or PM2527	3.7.3.1.	
Value of the base resistor R1817	R1817 is selected with transistor TS1807	Adjust mains voltage so that the voltage across C1809 is ± 90V 1kΩ in parallel with C1809 voltage across C1809 must be approximately 4V	Isolated transformer 1kΩ (0,5W) resistor digital multimeter	2422 529 00005 PM2517 or PM2527	3.7.3.1.	
Checking power supply with regulating circuit out of service		When the chopper is started: (mains: 40V) point 5 of T1802 a square wave of ± 70V_{pp} 18kHz Voltage across resistor of 22Ω must be 1,5V	50kΩ (0,5W) oscilloscope 22Ω (25W) digital multimeter	PM3243 or PM3262 5322 115 50006 PM2517 or PM2527	3.7.3.1.	
Regulating circuit	R1834	Increase mains voltage until the voltage over C1809 is ± 95V Pulse on the base of TS1807 can be varied with R1834 Power consumption must be ± 25W	oscilloscope watt-meter	PM3243 or PM3262	3.7.3.1.	3.46.
Current limitation		+45V: load 200Ω (25W) current limitation becomes active when the power output exceeds 30-35W. +45V output: when short-circuited then power supply in "hiccup" mode	200Ω (25W) digital multimeter	PM2517 or PM2527	3.7.3.1.	
Power supply	R1834	Mains input: local voltage Adjust +45V output to +45V ±100mV point 5 of T1802: square wave 18-22kHz with an ampl. of ±200V_{pp}	Digital multimeter oscilloscope	PM2517 or PM2527 PM3243 or PM3262	3.7.3.1.	3.46.
Cathode-ray tube circuit						
Trace rotation	R684	Time-base line parallel with horizontal lines of the graticule	–	–	3.7.4.1.	3.46.
Brilliance	R1327	A barely visible dot	–	–	3.7.4.2.	3.47.
Brilliance ratio	R1115	Ratio of intensity between MTB and DTB	–	–	3.7.4.3.	3.47.
Astigmatism.	R1344	A sharp trace with FOCUS potentiometer	Sine-wave 10kHz	PM5127 or PM5771	3.7.4.4.	3.47.
Geometry	R1346	Vertical lines must be straight	Sine-wave 10kHz 12V_{pp}	PM5127	3.7.4.5.	3.47.
Vertical Deflection						
Gain adjustment	R9 (front panel)	A trace height of exactly 6 divisions	Square wave 60mV_{pp} rise time 1n sec.	Tektronix PG506	3.7.5.1.	3.15.
LF gain	R132	A well adjusted attenuator for 100Hz	Square wave 100Hz 100MHz oscilloscope	PM5127 or PM5771 PM3262	3.7.5.2.	3.47.
Balance	R8 (front panel)	Minimum trace-jump when switching alternately between 5mV/div and 10mV/div.	–	–	3.7.5.3.	3.15.
DC/O balance	R129	Minimum trace-jump when alternately DC and O depressed	–	–	3.7.5.4.	3.47.
Variable gain balance	R141	Minimum time-base line jump when var. GAIN control is operated	–	–	3.7.5.5.	3.47.
Square-wave response		Square-wave free from overshoot and rounding and amplitude as indicated below:	20kHz square-wave rise time ⩽ 200n sec.	PM5127	3.7.5.6.	3.47.
		AMPL./DIV. switch — Trace height — Amplitude				
	C108	5mV — 6 div. ± 2% — 30mV 10mV — 6 div. ± 2% — 60mV 20mV — 6 div. ± 2% — 120mV				
	C101	50mV — 6 div. ± 2% — 300mV 100mV — 6 div. ± 2% — 600mV 200mV — 6 div. ± 2% — 1,2V				
	C109	500mV — 6 div. ± 2% — 3V 1V — 6 div. ± 2% — 6V 2V — 6 div. ± 2% — 12V				

Adjustment	*Adjusting element*	*Adjusting result*	*Recommended instrument and input signals*	*Example of measuring instrument*	*Chapter*	*Figures*
100kHz square-wave response	C122	A well adjusted attenuator for 100kHz. in all attenuator positions	Square-wave 100kHz 100MHz oscilloscope	PM5127 or PM5771 PM3262	3.7.5.7.	3.47.
Input capacitance		Square-wave free from overshoot and rounding and with an amplitude as indicated below:	100kHz square-wave via RC standardizer to input of oscilloscope	PM5127 and dummy probe 2 : 1 (1MΩ-15pF)	3.7.5.8.	3.47.
		AMPL./DIV switch — Trace height	Amplitude			
	C107	5mV — 3 div. ± 2%	30mV			
		10mV — 3 div. ± 2%	60mV			
		20mV — 3 div. ± 2%	120mV			
	C102	50mV — 3 div. ± 2%	300mV			
		100mV — 3 div. ± 2%	600mV			
		200mV — 3 div. ± 2%	1,2V			
	C111	500mV — 3 div. ± 2%	3V			
		1V — 3 div. ± 2%	6V			
		2V — 3 div. ± 2%	12V			
Intermediate and final Y-ampl.						
Normal/Invert balance	Channel A : R448 Channel B : R2648 Channel C : R2848 Channel D : R2448	Minimum trace jump when NORMAL/INVERT is operated	–	–	3.7.6.1.	3.46.
A+B balance adjustment	R548	The trace must be on the horizontal centre-line of the graticule	–	–	3.7.6.2.	3.46.
Square-wave response	Intermediate ampl.: Channel A : C402 - C416/R442	Pulse top as straight as possible Maximum pulse top error 0,1 division	100kHz square-wave Rise time ⩽ 1n sec.	Tektronix PG506	3.7.6.3.	3.46.
	Channel B : C2602 - C2616/R2642	AMPL./DIV. switch to 20mV/div. AMPL./DIV. switch to 0,1V/div.	$120mV_{pp}$ $600mV_{pp}$			
	Channel C : C2802 - C2816/R2842	AMPL./DIV. switch to 0,5V/div.	$3V_{pp}$			
	Channel D : C2402 - C2416/R2442					
	Final Y-amplifier: C603/R619 C606/R621 R622					
Trigger balance	Intermediate amplifier:					
	R379 (A)	Spot in the centre of the screen	–	–	3.7.6.4.	3.46.
	R2579 (B)	Spot in the centre of the screen				
	R2779 (C)	Spot in the centre of the screen				
	R2379 (D)	Spot in the centre of the screen				
Composite trigger balance	R531	Spot in the centre of the screen	–	–	3.7.6.4.	3.46.
EXT. trigger balance	R705	Spot in the centre of the screen	–	–	3.7.6.4.	3.46.
LINE triggering	R715	Mains deflection must be symmetrical around the centre of the graticule	–	–	3.7.6.4.	3.46.
Y-amplifier gain adjustment	R641 (R645)	Gain control R9 (front panel) in its mid-position Then gain must be readjusted with R641	Square-wave $60mV_{pp}$ Rise time 1n sec.	Tektronix PG506	3.7.6.5.	3.46.
Horizontal deflection *Main time base*						
Stability	R873	R873: 20° past the point where the time-base line ceases to be displayed	–	–	3.7.7.5.	3.47.
Time coefficients	R1223	X1–8 centre periods exactly 8 divisions	Time-marker signal 1m sec-ampl. 600mV	Tektronix TG501	3.7.7.6.	3.47.
	R1209	X5–8 centre periods exactly 8 divisions	200μ sec. – 600mV			
	R914	X1–8 centre periods exactly 8 divisions	10msec. – 600mV			
Linearity and horizontal positioning	C1203 C1208	8 centre-cycles must be 1 cycle/division	Time-marker signal 0,01 μ sec.	Tektronix TG501	3.7.7.7.	3.47.
Delayed time-base						
Stability	R1064	R1064: 20° past the point where the time base line ceases to be displayed	–	–	3.7.7.10.	3.47.
Time coefficients	R1097	8 centre periods exactly 8 divisions ±2,5%	Time-marker signal 1msec., ampl. 600mV	Tektronix TG501	3.7.7.11.	3.47.
Delay-time calibration	R987	Dial knob to 1.00–intensified part on the beginning of the second period	Square-wave 1kHz	PM5127 or PM5771	3.7.7.13.	3.47.
	R979	Dial knob to 9.00–intensified part on the beginning of the 9th period.	Square-wave 1kHz			

Adjustment	*Adjusting element*	*Adjusting result*	*Recommended instrument and input signals*	*Example of measuring instrument*	*Chapter*	*Figures*
Gain adjustment of the preamplifier for ext. X-deflection	R1131	Horizontal deflection via Ya (6 div.) X deflection must be 6 div. (± 10%)	Sine-wave 50kHz 6 divisions height	PM5127 or PM5771	3.7.7.14.	3.47.
DC output level of the preamplifier for ext. X-deflection	R1132	Base of TS1071 to earth potential then the spot must be in the horizontal centre of the screen (± 1 division)	–	–	3.7.7.14.	3.47.
X-deflection with mains signal	R1841	Trace-width must be 10 div. ± 1 div.	–	–	3.7.7.16.	3.46.
Calibration						
Calibration voltage	R1362	Square-wave signal of $3V_{pp}$, frequency 2kHz ± 2% Cal. current 6mA ± 1%	Oscilloscope	PM3262	3.7.8.	3.47.

3.7.3. Power supply

Warning: Use an isolating mains transformer when working in the power supply unit. Bear in mind that the main part of this unit is connected direct to the mains. As it is preferred to check the proper function of the power supply with adjustable mains voltage, use of a variable transformer (insulated version) is recommended.

Attention: The power supply unit is provided with a pre-set potentiometer R1834 which controls the d.c. output of the circuit. DO NOT READJUST THIS POTENTIOMETER UNLESS IT IS STRICTLY NECESSARY.
A consequence of readjusting this potentiometer is that all d.c. output voltages change, so that several circuits of the oscilloscope (e.g. time base sweep) must be recalibrated.
In the factory this potentiometer has been adjusted to the nominal value of the +45 V output. This voltage must be +45 V, + or −100 mV.

General

The best way to check the power supply is, when this unit is connected to the normal circuitry of the PM 3244 .
Provisions have been taken that the unit, after being taken out, remains connected to the instrument.
To facilitate the removal, first disconnect the various connections of the power supply unit.
The supply currents can be measured on each contact of the power supply output connectors. To disconnect one contact of a connector carefully press (twice) the spring at the side of the contact and lift the contact out. Inserting an additional contact provided with a piece of extension wire simplifies current measurement. After replacing the original contact check the spring locking-action to prevent the contact from coming loose later-on.

When the power supply unit is overloaded, the current limitation is actuated. As a result of this, the power supply goes in the "hiccup" mode (2 seconds cycle time approx.). This is caused by, successively, slow charging of the capacitor C1809, starting of the chopper, activation of current limiting transistor TS1808, discharging of the regulator circuit capacitor and so on.
Another reason for the power supply going in the "hiccup" mode is, when the switching transistor TS1807 gets no base current from the regulator circuit. In this case capacitor C1809 is slowly charged until the chopper circuit starts which causes the discharge of the capacitor in a short time, and so on.
If necessary, the power supply unit only, can be checked with the aid of a dummy load, consisting of load resistors and capacitors, see fig. 3.45.
If a fault is suspected in the power supply, the following procedure may help you to find what is wrong.

Note: The power supply must always be loaded with the nominal load.

Required instruments

- Variable mains transformer with isolated windings (e.g. Philips bench model 2422 529 00005 or panel model 2422 529 00006; input 220 V, output 0-248 V/3A).
- Watt meter (to measure mains power input).
- Oscilloscope (5 MHz bandwidth) e.g. PM 3243.
- Resistor 100 Ω, 25 W (5322 115 50015).
- Resistor 22 Ω, 25 W (5322 115 50006).
- Resistor of 1 kΩ and 50 kΩ, 0,5 W.

3.7.3.1. Checking procedure

In the first part of this procedure the current gain of the switching regulator transistor is checked (and the value of the base resistor R1817).
Then the power supply circuit is checked while the regulating circuit is out of service (switching regulator transistor short-circuited). In this case always check that the voltage across C1809 never exceeds the sum of the voltage across GR1806 and GR1807.
Next the regulating circuit and current limitation is checked.

Proceed as follows:

- Connect the isolating/variable transformer to the mains.
- Connect the power supply unit in series with a 22 ohm, 25 W resistor and via a Watt-meter to the isolating/variable transformer.
- Remove current sensing transistor TS1808.
- Set the variable transformer to 0 volt.
- Switch on the oscilloscope and increase the variable transformer output to 40 V.
- Check that the voltage across C1809 amounts to approx. 56 V (the chopper circuit is not oscillating).
- If this voltage across C1809 does not appear, check the ripple eliminator circuit (TS1801 and TS1802), R1819 and check the chopper circuit on short-circuit.
- Switch-off the instrument.
- After the voltage across C1809 has completely disappeared, switch-on again and check that the voltage across C1809 is present again after approx. 2 seconds.
  (The speed of charging depends on the current gain of TS1807 and the value of R1817).

R1817

- Increase the power supply input voltage until the voltage across C1809 amounts to 90 V.
- Connect a 1 kohm (0,5 W) resistor in parallel to C1809.
- The voltage across C1809 must now be approximately 4 V.
- If this 4 V can not be reached, change unit TS1807.
- Remove the resistor 1 kohm (0,5 W).

The unit comprises a transistor BDY93 or BUX82 and a selected resistor R1817. This transistor and resistor is selected according to the following procedure.
First the transistor is preheated during 100 hours in an oven at 125 ^{o}C. The reason for this is that under the influence of heat the current gain of this transistor decreases to a certain value. This phenomena formerly caused that the power supply of a new instrument did not start (especially in a cold environment) after the instrument had been used for some time.
Now the power transistors are preheated, the problem mentioned above has been abolished.

After 100 hours of preheating the transistors are selected for current gain (hfe). A current of 0,3 mA is applied to the base and the collector current is measured:

IC = 2,4 ... 3,6 mA; R1817 must be 27,4 k,
IC = 3,6 ... 5,4 mA; R1817 must be 36,5 k,
IC = 5,4 ... 8,1 mA; R1817 must be 56,2 k.

After that a current of 10 mA is applied to be base and if the collector current is less than 250 mA (at a collector voltage of 50 Volt) the transistor is rejected.

The production of the present TS1807 transistor type BDY93 is stopped within some time.
The successor for this transistor will be the type BUX82. In future this transistor will be delivered together with a selected resistor R1817 under the same code number as the BDY93 (5322 130 44707).
The selection procedure for the new type will be the same as used for the old type except for the 0,3 mA base current selection. The collector current ranges are:

IC = 2,4 ... 3,6 mA, R1817 must be 27,4 k,
IC = 3,6 ... 5,4 mA, R1817 must be 36,5 k,
IC = 5,4 ... 8,1 mA, R1817 must be 56,2 k,
IC = 8,1 ... 11,4 mA, R1817 must be 78,4 k.

- Adjust the mains input voltage to 40 V.
- Short-circuit emittor-collector of TS1807.
- Start the chopper circuit (TS1804, TS1806) by connecting for a short moment the base of TS1804 via a 50 kohm (0,5 W) resistor to point 4 of transformer T1802.
- Check the voltage on point 5 of T1802. This must be a square wave of approx. 70 V_{pp}, frequency approx. 18 kHz.
- The voltage across the 22 ohm series resistor in the mains input must be 1,5 V.
- If the chopper does not oscillate, check the chopper circuit itself.
  If the chopper goes in the "hiccup" mode when the 50 kohm resistor remains connected, check the d.c. output circuits and the circuit connected to points 7 and 8 of T1802.
- Remove the 22 ohm resistor in the mains input.

- Increase the mains input voltage until the voltage over C1809 amounts to 100 V (not higher, otherwise the Z-diodes GR1806 and GR1807 will blow up).
  The chopper must start automatically.
- Check the pulse on the base of TS1807.
  Adjust with the variable transformer the voltage across C1809 to ± 95 V check that this pulse can be varied with R1834. If not check the regulator circuit (see fig. 3.46).
- The power consumption must be 25 W approx.
- Remove the short-circuit across TS1807; check that the pulse on the base of TS1807 changes at this moment.
- Fit current sensing transistor TS1808.
- Check that the chopper circuit cuts out (goes in the "hiccup" mode) when the load of the power supply is increased by approx. 50%. To this end connect a 200 ohm 25 W resistor to the +45 V output. The current limitation goes "on" when the power output exceeds 30-35 W.
  Also when the +45 V output is short-circuited, the power supply goes in the "hiccup" mode.
- Adjust the mains input voltage with the variable transformer to the nominal local voltage.
- If necessary adjust the +45 V output voltage (+ or −100 mV is allowed) with the aid of R1834 (fig. 3.46).
- Check again the voltage on point 5 of T1802 with an oscilloscope. The frequency must be 18-22 kHz; check the shape of the chopper voltage; this must be a square wave of ± 200 V_{pp}.
- Vary the mains voltage between 90 and 248 V.
  Check that the +45 V output remains constant (between + or −200 mV).
  Check the 50% overload current limitation at 248 V.

3.7.3.2. Waveforms in the power supply unit (fig. 3.11)

(Photographs taken from storage oscilloscope PM 3243 with a 10 : 1 attenuator probe).

1. Mains ripple eliminator (TS1801)

a. A.C. Voltage on the emitter of TS1801.
b. A.C. Voltage on the collector of TS1801.
Both voltages are measured with respect to the negative pole of electrolytic capacitor C1806.
Mains voltage 220 V.
PM 3243 settings: 0,5 V/DIV; 5 ms/DIV; triggering from the mains.

2. Regulator input voltage versus voltage across switching transistor TS1807

a. Voltage on p3 with respect to p2 of IC1801.
b. Collector-emitter voltage of TS1801; lower line is 0 V.
Mains voltage 220 V.
PM 3243 settings: 20 mV/DIV for A; 100 V/DIV for B (100 : 1 attenuator probe and 1 V/DIV)
20 ms/DIV; external triggering from p5 of T1802.

3. Chopper

a. Voltage between p2 and p3 of transformer T1801.
b. Voltage between p7 and p8 of transformer T1802
Mains voltage 220 V.
PM 3243 settings: 0,5 V/DIV; 10 μs/DIV; external triggering from p5 of T1802.

4. Switching transistor TS1807

Current flowing through R1819.
a. Mains voltage 110 V.
b. Mains voltage 220 V.
PM 3243 settings: 50 mV/DIV (=25 mA/DIV); 20 μs/DIV; external triggering from p5 of T1802.

5. Regulator input voltage at 220 V and 110 V mains voltage

Voltage on p3 with respect to p2 of IC1801.
a. at 220 V.
b. at 110 V.
PM 3243 settings: 20 mV/DIV; 20 ms/DIV; external triggering from p5 of T1802.

6. Switching-on period

a. Voltage across R1819.
b. Voltage on p8 of IC1801 with respect to p1 and p10.
Lower line is 0 V.
Mains voltage 220 V.
PM 3243 settings: 5 ms/DIV; 20 mV/DIV for A; 0,1 V/DIV for B; external triggering from p5 of T1802; single shot.

7. Switching-on period

As photograph 6a, but with PM 3243 setting of 50 ms/DIV.

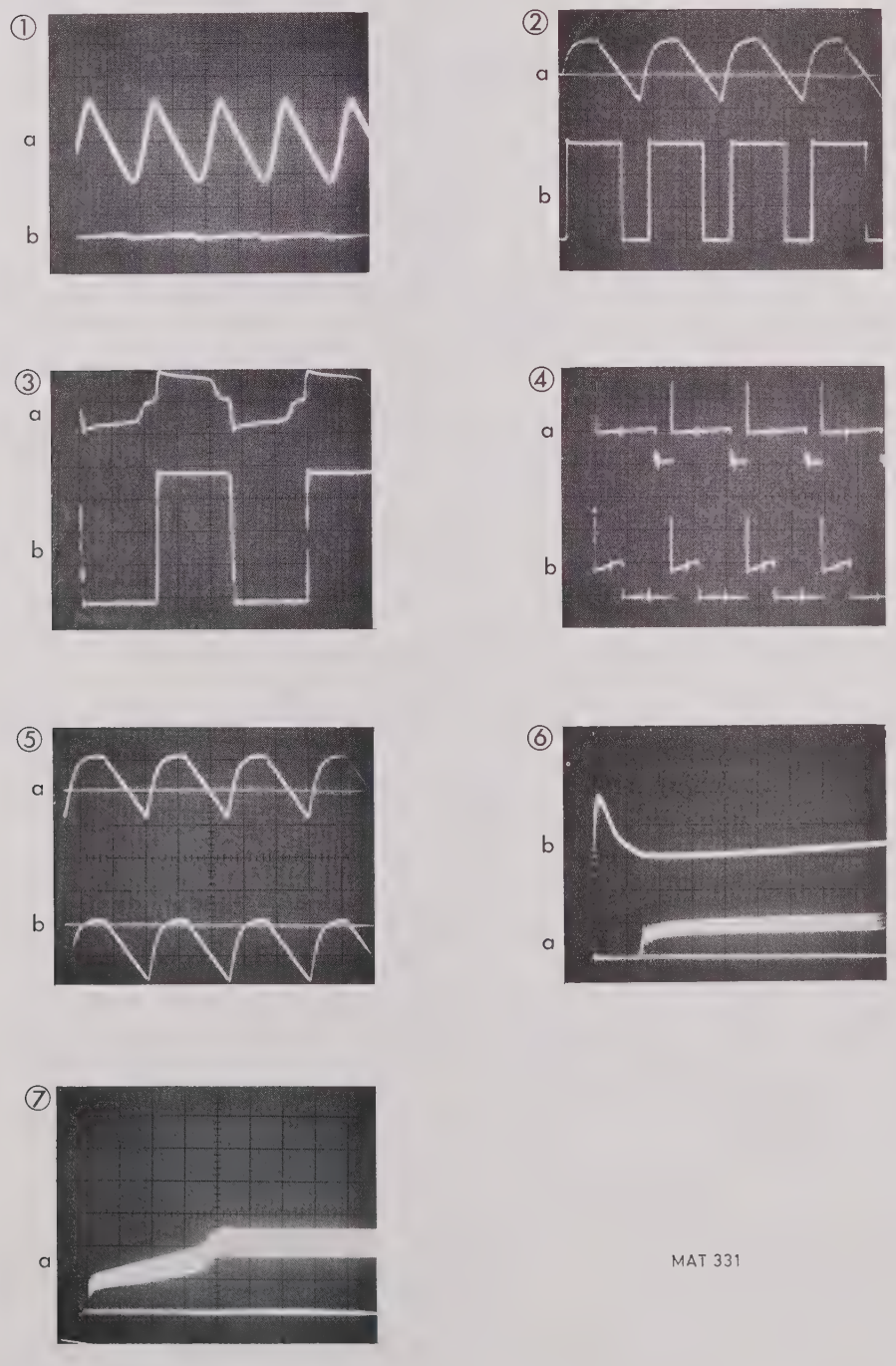

Fig. 3.11. Waveforms in the power-supply unit.

3.7.4. Cathode-ray tube circuit

3.7.4.1. Trace rotation, R684 (see fig. 3.46)

- Set the INTENS and FOCUS controls for a sharp, well-defined trace.
- Depress button A of the vertical-display mode switches.
- Depress button MAIN TB of the horizontal-deflection controls.
- Centre the time-base line, using the POSITION controls.
- Check that the time-base line runs exactly parallel with the horizontal lines of the graticule; if necessary readjust TRACE ROT. potentiometer R684.

3.7.4.2. Intensity, R1327 (see fig. 3.47)

- No vertical deflection.
- Depress button EXT X DEFL of the horizontal-deflection controls (no horizontal-deflection).
- Turn the INTENS potentiometer 90° from left-hand stop.
- Set the horizontal POSITION control in its mid-position.
- Check that the dot is barely visible.
  If necessary, readjust potentiometer R1327 on the Z-unit.

3.7.4.3. Intensity ratio, R1115 (see fig. 3.47)

- Depress button A of the vertical-display mode switches.
- Depress button MAIN TB of the horizontal-deflection controls.
- Turn the DELAY TIME control to its mid-position.
- Set the MAIN TIME/DIV switch to 1 ms and the DEL'D TIME/DIV switch to .2 ms.
- Set the INTENS potentiometer to a position 180° from its anti-clockwise stop.
- Check that the trace of the main time-base generator is just visible over the entire screen and that the portion determined by the delayed time-base generator is brighter. If necessary, readjust the INTENS RATIO potentiometer R1115 on time base unit.

3.7.4.4. Focus and astigmatism, R1344 (see fig. 3.47)

- Depress button A of the vertical-display mode switches.
- Depress button MAIN TB of the horizontal-deflection controls.
- Set the delayed time-base TIME/DIV switch to OFF.
- Apply a sinewave signal at a frequency of 10 kHz to input socket A.
- Adjust the trace height to 6 divisions, using the AMPL switch and venier.
- Set the MAIN TIME/DIV switch and the LEVEL potentiometer to such a position that several complete cycles are displayed.
- Set the INTENS potentiometer for normal brilliance.
- Check that a reasonably sharp trace can be obtained with the aid of the FOCUS potentiometer. If necessary readjust astigmatism potentiometer R1344 on Z-unit.

3.7.4.5. Geometry, R1346 (see fig. 3.47)

- Depress button A of the vertical-display mode switches.
- Depress button MAIN TB of the horizontal-deflection controls.
- Set the DEL'D TIME/DIV switch to OFF.
- Apply a sinewave voltage of 12 V_{pp}, frequency approximately 10 kHz to input socket A.
- Set the channel A AMPL switch to .1 V/DIV.
- Set the MAIN TIME/DIV switch to .2 ms.
- Check that the displayed vertical lines are straight; if necessary, readjust potentiometer R1346 on Z-unit.
- Remove the input signal.

3.7.5. Vertical deflection

The four input attenuators are completely identical.
Therefore, only one channel is described.

3.7.5.1. Gain adjustment (front panel)

- Depress push-button A of the vertical display mode switches.
- Depress push-button DC of the AC-0-DC switch.
- Depress the PULL TO INVERT switch, incorporated in the AMPL/DIV continuous control.
- Set the AMPL step attenuator to 10 mV/DIV.
- Set the AMPL continuous controls to CAL position.
- Apply a square-wave signal with a maximum rise-time of 1 ns, a peak-to-peak value of exactly 60 mV and a frequency of 1 kHz to input socket A.
- Set the MAIN TB switch to a suitable position.
- Obtain a stationary trace with the aid of the LEVEL potentiometer.
- Check that the trace height is 6 divisions. If necessary, adjust the GAIN potentiometer on the front panel.

3.7.5.2. LF gain adjustment, R132 (see fig. 3.47)

To be sure that the attenuator is well adjusted connect an oscilloscope e.g. PHILIPS PM 3262 to its output.
- Apply a 100 Hz square wave signal to the input of the attenuator.
- Readjust R132 if the gain is not well adjusted.

The attenuator has in the 5 mV/div. position an attenuation of 1,25x.
The attenuator output must have its normal load of approximately 50 ohms e.g. the intermediate amplifier.

3.7.5.3. Balance adjustment (front panel)

- Depress the A button of the vertical-display mode switches.
- Depress the 0 button of the AC-0-DC switch.
- Switch the AMPL step attenuator between positions 5 mV/DIV and 10 mV/DIV.
- Check that the trace does not jump. If necessary, readjust the BAL potentiometer on the front panel.

3.7.5.4. DC/0 balance, R129 (see fig. 3.47)

- Set R141 (output DC offset compensation) to its mid position.
- Set the AMPL/DIV switch to 5 mV/div.
- Depress alternately the DC and 0 coupling switches and adjust R129 to minimum time-base line jump.

3.7.5.5. Variable gain balance, R141 (see fig. 3.47)

- Centre the time-base line, using the POSITION control.
- Adjust R141 (output DC offset compensation) to minimum time-base line jump when operating the var. GAIN control.

3.7.5.6. 20 kHz square wave response adjustment, C108, C109, C101 (see fig. 3.47)

- Depress button A of the vertical-display mode switches.
- Set the MAIN TIME/DIV switch to 20 μs.
- Depress button DC of the AC-0-DC switch.
- Apply a square-wave signal, frequency approximately 20 kHz, rise time $\leqslant$ 200 ns and amplitude as indicated in the table below, to input socket A.
- Check that the displayed square-wave is free from overshoot and rounding.

AMPL/DIV switch SK19	Input signal on channel A BU3	Adjustment	Trace height
5 mV	30 mV		6 div. ± 2%
10 mV	60 mV	C108	6 div. ± 2%
20 mV	120 mV		6 div. ± 2%
50 mV	300 mV		6 div. ± 2%
100 mV	600 mV	C101	6 div. ± 2%
200 mV	1,2 V		6 div. ± 2%
500 mV	3 V		6 div. ± 2%
1 V	6 V	C109	6 div. ± 2%
2 V	12 V		6 div. ± 2%
Max. admissible pulse-top error: 2%			

3.7.5.7. 100 kHz square-wave response adjustment, C122 (see fig. 3.47)

Besides the 100 kHz adjustment points in the intermediate amplifier the attenuators have a 100 kHz adjustment trimmer C122. This trimmer works on all attenuator positions. To be sure that the attenuator unit is well adjusted, connect an oscilloscope with a bandwidth of 50 MHz or more e.g. PHILIPS PM 3262 to the output of the attenuator and set C122 to maximum square-wave response. The attenuator output must have its normal load of approx. 50 ohms (for instance the intermediate amplifier). The attenuator has in the 5 mV/div position an attenuation of 1,25x.

3.7.5.8. Input capacitance adjustment (see fig. 3.47)

- Apply a 100 kHz square-wave signal with the voltages mentioned in the table above via an input RC Standardizer of 1 MOhm/15 pF to input socket A.
- Check that the displayed square-wave is free of rounding and overshoot; maximum admissible pulse-top error: 2%; if necessary, readjust in accordance with table below.

AMPL/DIV switch SK19	Via Standardizer Input to BU3	Adjustment	Trace height
5 mV	30 mV		3 div. ± 2%
10 mV	60 mV	C107	3 div. ± 2%
20 mV	120 mV		3 div. ± 2%
50 mV	300 mV		3 div. ± 2%
100 mV	600 mV	C102	3 div. ± 2%
200 mV	1,2 V		3 div. ± 2%
500 mV	3 V		3 div. ± 2%
1 V	6 V	C111	3 div. ± 2%
2 V	12 V		3 div. ± 2%

3.7.5.9. Bandwidth

- Depress push-button A of the vertical display mode switches.
- Set the AMPL/DIV control to .1V/DIV and the continuous control to CAL.
- Apply a sine wave signal of 800 mV_{pp}, 50 kHz to the input of channel A.
- Trace height must be 8 divisions.
- Increase the generator frequency to 50 MHz while retaining the amplitude of the input signal at 800 mV_{pp}.
- Check that the trace height is at least 5,6 divisions.

3.7.5.10. Common mode rejection channel A+B (C+D)

- Depress push-button A+B (C+D) of the vertical display mode switches.
- Set the channel A (C) and B (D) AMPL/DIV switch to .1V/DIV and the continuous controls to CAL.
- Push the NORM/INVERT switch of channel A to NORMAL.
- Pull the NORM/INVERT switch of channel B to INVERT.
- Apply a sine wave signal of 2,4 V_{pp} to the inputs of channels A (C) and B (D) simultaneously.
- Check the rejection rate in accordance with the following table:

Input frequency	Max. trace height	Rejection factor
100 kHz	0,24 DIV	100
1 MHz	0,24 DIV	100

- Remove the input signals.

3.7.5.11. Chopped mode (see fig. 3.47)

A display of 0.5 μs or 2 μs can be selected with the miniature slider switch SK201 on the channel selection unit.
The 0.5 μs position gives high resolution at fast single-shot displays.
The 2 μs position gives increased brightness at high sweep speeds.

- Set the m.t.b. TIME/DIV switch to 10 msec.
- Depress all push-buttons of the vertical display mode switches.
- Depress push-button CHOP and 0 of the AC-0-DC input signal coupling switches of channels A, B, C and D.
- Six lines must be displayed on the screen without any background light.

3.7.5.12. Alternate mode

- Depress push-button ALT.
- Set the m.t.b. TIME/DIV switch to 10 μsec.
- Six lines must be displayed on the screen alternately.
- Check that the six channels are switched over after every sweep of the sawtooth voltage (set the m.t.b. TIME/DIV switch to 50 msec).

3.7.5.13. Effective signal delay

- Depress push-button A of the vertical display mode switches.
- Depress push-button A of the m.t.b. trigger source switches.
- Pull the TB MAGN switch to x5.
- Set the AMPL/DIV switch to .2 V/DIV.
- Apply a square-wave of approx. 600 mV_{pp}, frequency 100 kHz with a rise time $\leqslant$ 1 nsec to the input.
- Adjust the m.t.b. LEVEL potentiometer for a stable, stationary display.
- Set the AMPL/DIV switch to .1 V/DIV.
- Turn the INTENS control to maximum intensity.
- Check that the effective delay time T is larger than 1 DIV (see fig. 3.12).

Fig. 3.12. Effective signal delay.

3.7.5.14. Dynamic range and position range

- Set the TB MAGN to 1x.
- Set the m.t.b. TIME/DIV switch to 0.05 μsec/div.
- Depress push-button A of the vertical display mode switches.
- Apply a sine wave of 2,4 V_{pp}, frequency 15 MHz to the input.
- Set the AMPL/DIV switch to .1 V/DIV and the continuous control to CAL.
- Check that the top and bottom parts of the sine wave can be displayed by turning the vertical POSITION control.
- Check that the displayed sine wave shows no distortion over the whole vertical POSITION range.

3.7.6. Intermediate and final Y amplifier

3.7.6.1. Normal/Invert balance (see fig. 3.46)

- Depress buttons A, B, C, D of the vertical display switches.
- Adjust the following potentiometers so that the corresponding trace does not jump when the 'PULL TO INVERT' switch is operated.
  ch. A : R448
  ch. B : R2648
  ch. C : R2848
  ch. D : R2448
  These potentiometers are located on the intermediate amplifier unit.

3.7.6.2. A + B balance adjustment (see fig. 3.46.)

- Depress buttons A, A+B and B of the vertical display switches
- Shift the three traces so that they are superimposed on each other, using the ch. A and ch. B POSITION controls on the front panel.
- Adjust potentiometer R548 (located on the intermediate amplifier unit) so that the trace is on the horizontal centre-line of the graticule.

The C+D balance is now also correct.

3.7.6.3. Square-wave response (see fig. 3.46.)

- Depress push-button A of the vertical display mode switches.
- Set the AMPL/DIV switch to 20 mV/div.
- Set the m.t.b. TIME/DIV switch to .05 μsec.
- Apply a square wave signal of 120 mV_{pp}, rise time $\leqslant$ 1 nsec, frequency 100 kHz to the input of the channel to be measured.
- Check that the pulse-top is as straight as possible.
  Maximum pulse-top error including ringing and overshoot 0,1 division.
- Adjustments on the intermediate amplifier for:
  ch. A : C402-C416/R442
  ch. B : C2602-C2616/R2642
  ch. C : C2802-C2816/R2842
  ch. D : C2402-C2416/R2442
- Adjustments on the final Y amplifier:
  C603/R619
  C606/R621
  R622
- Check the square-wave response also with an input voltage of 0,6 V (AMPL/DIV switch to 0,1 V/div) and with an input voltage of 3 V (AMPL/DIV switch to 0,5 V/div).

3.7.6.4. Trigger balance adjustments (see fig. 3.46)

- Depress pushbutton A of the vertical display switches.
- Depress pushbutton MAIN TB of the horizontal display switches.
- Set TB MAGN. to x1 position.
- Depress pushbutton AUTO of the main timebase mode switches.
- Set main time-base sweep to 0.5 ms/DIV.
- Depress pushbutton A of the main time-base trigger source switches.
- Set input coupling switches of all vertical deflection channels in position DC.
- Adjust horizontal POSITION control on the front panel so that the trace starts at the extreme left-hand graticule line.
- Adjust channel A POSITION so that the trace is on the horizontal centre graticule line.
- Depress button EXT X DEFL of the horizontal display switches.
- Adjust potentiometer R379 (intermediate amplifier unit) so that the spot is in the centre of the graticule.
- Depress pushbutton B of the main time-base trigger source switches.
- Adjust potentiometer R2579 (intermediate amplifier unit) so that the spot is in the centre.
- Depress pushbutton C of the main time-base trigger source switches.
- Adjust potentiometer R2779 (intermediate amplifier unit) so that the spot is in the centre.
- Depress pushbutton D of the main time-base trigger source switches.
- Adjust potentiometer R2379 (intermediate amplifier unit) so that the spot is in the centre.

Composite trigger blance adjustment, R531 (see fig. 3.46)

- Depress both push-buttons A and B of the m.t.b. trigger source switches for composite triggering.
- Adjust potentiometer R531 so that the spot is in the centre of the screen.

EXT. trigger balance, R705 (see fig. 3.47)

- Depress both push-buttons C and D of the m.t.b. trigger source switches.
- Adjust potentiometer R705 so that the spot is in the centre of the screen.

LINE adjustment, R715 (see fig. 3.28)

- Depress both push-buttons B and C of the m.t.b. trigger source switches.
- Select the value for R715 (7.15 k ... 9,53 kohms) so that the mains deflection is symmetrical around the centre of the graticule.

3.7.6.5. Y-amplifier gain adjustment R641 (see fig. 3.46)

After adjusting the GAIN control on the front panel (see 3.7.5.1.) this potentiometer should be in his mid-position.
If not, adjust potentiometer R641.
If the setting cannot be reached with R641, change R645 to a suitable resistance value between 249 ohm and 1 kohm.
Check that the control range of the AMPL/DIV continuous control is at least 1:2,6 to 1:3,5.

3.7.7. Horizontal deflection
Main time base.

3.7.7.1. Trigger slope and level

- Depress button A of the vertical-display mode switches.
- Set the channel A AMPL switch to .2 V/DIV.
- Depress the AC button of the channel A AC-0-DC switch.
- Apply a sinewave signal with an amplitude of 1,6 V to input socket A, frequency approximately 30 kHz.
- Set the MAIN TIME/DIV switch to such a position that a few cycles of the input sinewave are displayed.
- Push the SLOPE switch to its + position.
- Check that the time-base generator starts on the positive-going part of the sinewave and moves upwards when the LEVEL potentiometer is turned clockwise.
- Pull the SLOPE switch to its – position.
- Check that the time-base generator starts on the negative-going part of the sinewave.
- Set the AMPL switch to .1 V/DIV.
- Position the trace in such a way that the trigger point is visible.
- Check that it is possible to shift the starting point of the sinewave over 16 divisions, by means of the LEVEL control.
- Push the SLOPE switch to its + position.
- Position the trace in such a way that the trigger point is visible.
- Check that it is possible to shift the starting point of the sinewave over 16 divisions, by means of the LEVEL control.
- Check that the maximum control range of the LEVEL potentiometer does not exceed 32 divisions.

3.7.7.2. Trigger sensitivity

- Adjust the main time-base LEVEL potentiometer for a stationary display.
- Set the MAIN TIME/DIV switch to such a position that a reasonable number of sinewaves is written on the screen.
- Set the trigger sensitivity in accordance with the table below.

Input signal on	Frequency	MTB trigger selector SK9	Vertical display mode SK12 ... 17	MTB trigger source SK21	Trace height
BU3A	10 Hz	TRIG	A	A	0.4 div.
BU3A	10 kHz	TRIG	A	A	0,4 div.
BU3A	50 MHz	TRIG	A	A	0,8 div.
BU3A	50 MHz	AUTO	A	A	0,8 div.
BU3B	10 Hz	TRIG	B	B	0,4 div.
BU3B	50 MHz	TRIG	B	B	0,8 div.
BU3B	50 MHz	TRIG	B	A+B	0,8 div.
BU3C	10 Hz	TRIG	C	C	0,4 div.
BU3C	50 MHz	TRIG	C	C	0,8 div.
BU3D	10 Hz	TRIG	D	D	0,4 div.
BU3D	50 MHz	TRIG	D	D	0,8 div.
BU3D	50 MHz	TRIG	D	A+B	0,8 div.
BU3D	50 Hz	TRIG	D	B+C	0,2 div.
BU4(EXT.)	10 Hz	TRIG		C+D	140 mV
BU4	50 MHz	TRIG		C+D	600 mV

3.7.7.3. Hold off control

- Remove the input signal.
- Set the m.t.b. TIME/DIV switch to 5 μsec./div.
- The intensity of the time base line must be adjustable with the HOLD OFF control.

3.7.7.4. Single-sweep operation

- Set the AMPL switch to .2 V/DIV.
- Set the LEVEL control to mid-range.
- Set the MAIN TIME/DIV switch to .1 s.
- Apply a signal that gives a trace height of approximately 8 divisions to input socket YA.
- Depress push-button A of the vertical display mode switches
- Depress the 0 button of the channel A AC-0-DC switch.
- Push the SINGLE button of the trigger-mode controls.
- Check that the NOT TRIG'D lamp lights up.
- Depress button AC of the channel A AC-0-DC switch.
- Check that the trace is written once and that the NOT TRIG'D lamp is extinguished at the start of the sweep.

3.7.7.5. Stability R873 (see fig. 3.47)

- Depress push-button 0 of the AC-0-DC switch.
- Depress button MAIN TB of the horizontal-deflection controls.
- Depress button TRIG of the trigger-mode controls.
- Set the DEL'D TIME/DIV switch to OFF.
- Set the m.t.b. TIME/DIV switch to 0.2 msec/div.
- Rotate the main time-base LEVEL control fully anti-clockwise.
- Turn STAB potentiometer R873 fully anti-clockwise.
- Check that there is a time-base line written.
- Rotate STAB potentiometer R873 approximately 20° past the point where the time-base line ceases to be displayed.
- Depress button AUTO of the trigger-mode controls.
- Check that there is a time-base line written again.

3.7.7.6. Time coefficients, R1223, R1209, R914 (see fig. 3.47)

As the power supply may affect the sweep times, it must be checked before readjusting the sweep times, refer to 3.7.3.

- Depress button A of the vertical-display mode switches.
- Set the AMPL switch to .1 V/DIV.
- Depress button DC of the AC-0-DC switch.
- Depress button MAIN TB of the horizontal-deflection controls.
- Push the TB MAGN switch to position x1.
- Depress button AUTO of the trigger-mode controls.
- Set the MAIN TIME/DIV vernier control to CAL.
- Set the MAIN TIME/DIV switch to 1 msec.
- Depress button A of the trigger-source controls.
- Apply a time-marker signal at a repetition rate of 1 ms to input socket A, amplitude approximately 600 mV.
- Check that the 8 centre periods cover exactly 8 divisions; if necessary, readjust potentiometer R1223.
- Pull the TB MAGN switch to position x5.
- Set the time-marker generator to 200 μs.
- Check that the 8 centre cycles cover exactly 8 divisions; if necessary, readjust potentiometer R1209.
- Push the TB MAGN control to position x1.
- Set the MAIN TIME/DIV switch to 10 ms.
- Set the time-marker generator to 10 ms.
- Check that the 8 centre cycles cover exactly 8 divisions; if necessary, readjust potentiometer R914.
- Check that the control range of the TIME/DIV continuous control is 1:2,6 to 1:3,5.
- Check the remaining positions of the TIME/DIV switch; the centre 8 periods should always cover exactly 8 divisions, ± 2,5 %. On the end positions .5 s, .2 s, 1 μs and .05 μs the tolerance is ± 3,5 %.
- Also check that the length of the time-base line always exceeds 10 divisions.

3.7.7.7. Linearity and horizontal positioning, C1203, C1208 (see fig. 3.47)

- Set the MAIN TIME/DIV control to .05 μs.
- Pull the TB MAGN switch to its x5 position.
- Apply a time-marker signal with a pulse repetition frequency of .01 μs to input socket A.
- Check that the 8 centre cycles cover exactly 8 divisions.

- Check also that for the 8 centre cycles a display of 1 cycle/division is obtained; if necessary, readjust trimmer capacitors C1203 and C1208.
- Check that all other cycles have a width of 1 division by shifting the whole train of pulses across the screen. Do not take into account the first and last five cycles.
- Also check that with the X POSITION potentiometer fully anti-clockwise and fully clockwise the beginning and the end of the trace is written within the measuring graticule.

Delayed time base

3.7.7.8. Trigger slope and level

- Depress button DEL'D TB of the horizontal-deflection switch.
- Depress button A of the del'd time-base trigger-source controls.
- Set the channel A-AMPL switch to .2 V/DIV.
- Depress the AC button of the channel A AC-0-DC switch.
- Depress push-button TRIG of the d.t.b. trigger mode switches.
- Turn the DELAY TIME multiplier knob fully anti-clockwise.
- Set the MAIN TIME/DIV switch to 20 μs and the DEL'D TIME/DIV switch to 10 μs.
- Apply a sinewave signal with an amplitude of 1,6 V to input socket A, frequency approximately 30 kHz.
- Push the SLOPE switch of the delayed time-base generator to its + position.
- Check that the time-base generator starts on the positive-going part of the sinewave and shifts upwards when the LEVEL potentiometer is turned clockwise.
- Pull the SLOPE switch of the delayed time-base generator to its — position.
- Check that the time-base generator starts on the negative-going part of the sinewave.
- Set the AMPL switch to .1 V/DIV.
- Position the trace in such a way that the trigger point is visible.
- Check that it is possible to shift the starting point of the sinewave over 16 divisions by means of the delayed time-base LEVEL control.
- Push the SLOPE switch of the delayed time-base generator to its + position.
- Position the trace in such a way that the trigger point is visible.
- Check that it is possible to shift the starting point of the sinewave over 16 divisions by means of the delayed time-base LEVEL control.
- Check that the maximum control range of the LEVEL potentiometer does not exceed 32 divisions.

3.7.7.9. Trigger sensitivity

- Depress button DEL'D TB of the horizontal-deflection controls.
- Set the delayed time-base LEVEL potentiometer to obtain a stationary display.
- Set the MAIN TIME/DIV switch one position lower (longer sweep time) than the DEL'D TIME/DIV switch.
- Adjust the DEL'D TIME/DIV switch to such a position that a reasonable number of sinewaves is written on the screen (not for 20 Hz).
- Check the trigger sensitivity in accordance with the table below.

Input signal on	Frequency	Trigger mode SK11	Vertical display mode SK12 ... 17	DTB trigger source SK10	Trace height
BU3A	100 Hz	STARTS	A	A	0,4 div.
BU3A	10 kHz	STARTS	A	A	0,4 div.
BU3A	50 MHz	STARTS	A	A	0,8 div.
BU3B	100 Hz	STARTS	B	B	0,4 div.
BU3B	50 MHz	STARTS	B	B	0,8 div.
BU3B	50 MHz	STARTS	B	A+B	0,8 div.
BU3C	100 Hz	STARTS	C	C	0,4 div.
BU3C	50 MHz	STARTS	C	C	0,8 div.
BU3D	100 Hz	STARTS	D	D	0,4 div.
BU3D	50 MHz	STARTS	D	D	0,8 div.

3.7.7.10. Stability, R1064 (see fig. 3.47)

Depress button DEL'D TB of the horizontal-deflection controls.
- Depress button A of the delayed time-base trigger-source controls.
- Depress button 0 of the channel A AC-0-DC switches.
- Set the MAIN TIME/DIV switch to .5 ms.
- Set the DEL'D TIME/DIV switch to .2 ms.
- Depress pushbutton TRIG of the d.t.b. trigger mode switches.
- Turn the delayed time-base LEVEL control fully anti-clockwise.
- Turn STAB potentiometer R1064 fully clockwise
- Check that a time-base line is displayed.
- Rotate STAB potentiometer R1064 approximately 20^{o} beyond the point where the time-base line ceases to be displayed.
- Depress push-button STARTS of the d.t.b. trigger mode switches.
- Check that the time base line is displayed again.

3.7.7.11. Time coefficients, R1097 (see fig. 3.47)

- Depress button A of the vertical-display mode switches.
- Set the AMPL switch to .1 V/DIV.
- Depress button DC of the AC-0-DC switch.
- Rotate the DELAY TIME control fully anti-clockwise.
- Depress button DEL'D TB of the horizontal-deflection controls.
- Depress button AUTO of the main time-base trigger-mode controls.
- Depress button A of the delayed time-base trigger-source controls.
- Set the TIME/DIV continuous controls to the CAL positions.
- Set the m.t.b. and d.t.b. TIME/DIV switch to 1 msec/div.
- Apply a time-marker signal at a repetition rate of 1 ms and an amplitude of approximately 600 mV to input socket A.
- Check that the 8 centre periods cover exactly 8 divisions; if necessary, readjust potentiometer R1097.
- Check that the control range of the delayed time-base TIME/DIV contin. control is 1:2,6 to 1:3,5.
- Check the remaining positions of the DEL'D TIME/DIV switch.
  Keep the DELAY TIME control fully anti-clockwise during this check, and the MAIN TIME/DIV switch one position lower than the DEL'D TIME/DIV switch. In this way, the delayed time-base can complete an entire sweep.
- Check that the 8 centre periods always cover 8 divisions, ± 2,5 % except in the positions .1 μs and .05 μs, where the tolerance is ± 3,5 %.
- Check that in all positions of the DEL'D TIME/DIV switch the length of the time-base line exceeds 10 divisions.
- Check that no time-base line is written when the DEL'D TIME/DIV switch occupies the OFF position.
- Remove the input signal.

3.7.7.12. Delay time control

- Depress button A of the vertical-display mode switches.
- Depress button DC of the AC-0-DC switches.
- Depress button MAIN TB of the horizontal-deflection controls.
- Depress button AUTO and MAIN TB of the trigger-mode controls.
- Set the DEL'D TIME/DIV switch to 0,1 msec.
- Set the MAIN TIME/DIV switch to 1 ms.
- Depress push-button A of the m.t.b. and d.t.b. trigger source switches.
- Depress button A of the trigger-source controls.
- Rotate the TIME/DIV cont. controls to CAL.
- Apply a time-marker signal at a repetition rate of 1 ms.
- Set the LEVEL control of the main time-base for a triggered display.
- Check that the intensity modulation by the delayed time-base is visible over the entire range of the INTENS potentiometer.
- Check that the starting point of the delayed time-base can be continuously shifted along the main time-base line with the aid of the DELAY TIME control. Ignore the first and last half-divisions.

3.7.7.13. Delay-time calibration (see fig. 3.47)

(Start- and stop pot. meters R987 and R979; located on the small p.c. board underneath the c.r.t.)

- Set the delayed timebase sweep to .1 ms/DIV.
- Set the main timebase sweep to 1 ms/DIV.
- Depress pushbutton MAIN TB of the horizontal display switches.
- Depress pushbutton STARTS of the delayed timebase mode switches.
- Depress pushbutton A of the vertical display switches.
- Depress pushbutton A of the main timebase trigger source switches.
- Apply a 1 ms squarewave signal to the channel A input.
- Set the DELAY TIME multiplier dial knob to 1.00.
- Adjust 'start' potentiometer R987 (front-panel side) so that the beginning of the intensified part of the trace coincides with the beginning of the 2nd period.
- Set the DELAY TIME multiplier dial knob to 9,00.
- Adjust 'stop' potentiometer R979 so that the beginning of the intensified part of the trace coincides with the beginning of the 9th period.
- Repeat both adjustments for optimum results.

3.7.7.14. Gain and balance adjustment of the preamplifier for ext. X-deflection

Gain adjustment, R1131 (see fig. 3.47)

This adjustment must be carried out after the gain adjustment of the four channels and of the final Y-amplifier.

- Depress the push-button EXT.X deflection of the horizontal deflection controls.
- Set the d.t.b. TIME/DIV switch to OFF.
- Apply a sine wave of 6 divisions height and a frequency of 50 kHz to the input of channel A.
- Check that the horizontal deflection is about the same (6 div. ± 10 %) as the vertical deflection.
- If necessary, change R1131 to a resistance value between 18,7 and 21,5 kOhm to obtain the right X-deflection.
- Note that R1131 also influences the horizontal shift. Therefore, adjust R1131 first and afterwards R1132.

DC output level adjustment, R1132 (see fig. 3.47)

This adjustment must be carried out after the gain adjustment.

- Set the HORIZONTAL POSITION control so that the MTB line starts at the most left line of the graticule.
- Connect the base of TS1071 to earth potential.
- Depress the button EXT. X DEFL. of the horizontal-deflection controls.
- Check that the display shows a spot in the horizontal centre of the graticule (± 1 div.).
- If necessary, change R1132 to a resistance value between 31,6 and 40,2 kOhm to obtain the right X position of the spot.
- Remove the earth potential from the base of TS1071.

3.7.7.15. External X deflection

- Depress both push-buttons C and D of the m.t.b. trigger source switches.
- Apply a sine wave voltage of exactly 3 V_{pp}, frequency 10 kHz to the EXT input socket.
- Check that the trace-width is 6,5 to 10 divisions.

Bandwidth of the EXT X deflection

- Adjust the amplitude of the input signal to obtain a trace width of 6 divisions.
- Increase the frequency of the input signal to 1 MHz.
- Check that the trace width is at least 4,2 divisions.

3.7.7.16. X-deflection with the mains signal, R1841 (see fig. 3.46)

- Apply a sine wave (mains frequency) to the input of channel A.
- Depress push-button A of the vertical display mode switches.
- Depress push-button EXT X DEFL of the horizontal-deflection controls.
- Depress both push-buttons B and C (line) of the m.t.b. trigger source switches.
- Check that the trace width is 10 divisions, ± 1 div.; if necessary, readjust potentiometer R1841.

3.7.7.17. Phase difference

- Depress push-button A of the vertical display mode switches.
- Set the AMPL/DIV switch to 0,5 V/div.
- Depress push-button EXT X DEFL of the horizontal deflection controls.
- Depress push-button A of the m.t.b. trigger source switches.
- Depress push-button DC of the AC-0-DC switches.
- Apply a sine wave voltage of 3 V_{pp}, frequency 10 kHz to the input of channel A.
- Check that a solid line, at an angle of 45° is displayed.
- Increase the frequency of the input signal to 100 kHz.
- Check that the phase-error does not exceed 3°.
- See fig. 3.13. in which $\frac{b}{a}$ equals the sine of the phase error angle.

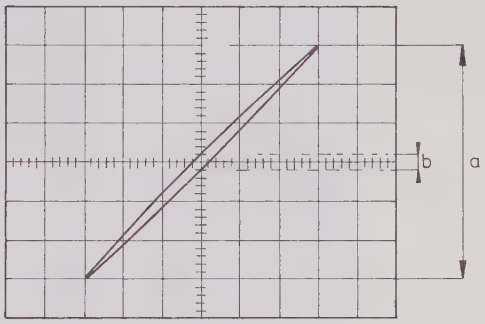

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Fig. 3.13. Phase difference in X-Y mode

3.7.8. Calibration unit, R1362 (see fig. 3.47)

- Check the calibration voltage for irregularities.
- Check that the amplitude of the square-wave voltage is 3 V_{pp} ± 0.7 %; if necessary, readjust R1362.
- Check that the frequency is 2 kHz ± 2 %.
- Check that the CAL current is 6 mA ± 1 %.

3.7.9. Mains voltage fluctuations

- Depress both push-buttons A and B of the vertical display mode switches.
- Depress CHOP of the display mode controls.
- Set the channel A and B AMPL/DIV switches to .5 V/div.
- Set the m.t.b. TIME/DIV switch and the m.t.b. LEVEL control for a stable, stationary display.
- Depress the push-buttons AC of the signal input coupling controls.
- Pull the TB MAGN switch to x5.
- Interconnect the CAL socket with the channel A and B input.
- Check that neither the trace width nor the trace height changes when the mains voltage is varied between 90 V and 260 V. Also check that the trace intensity does not change.

3.8. PARTS LIST

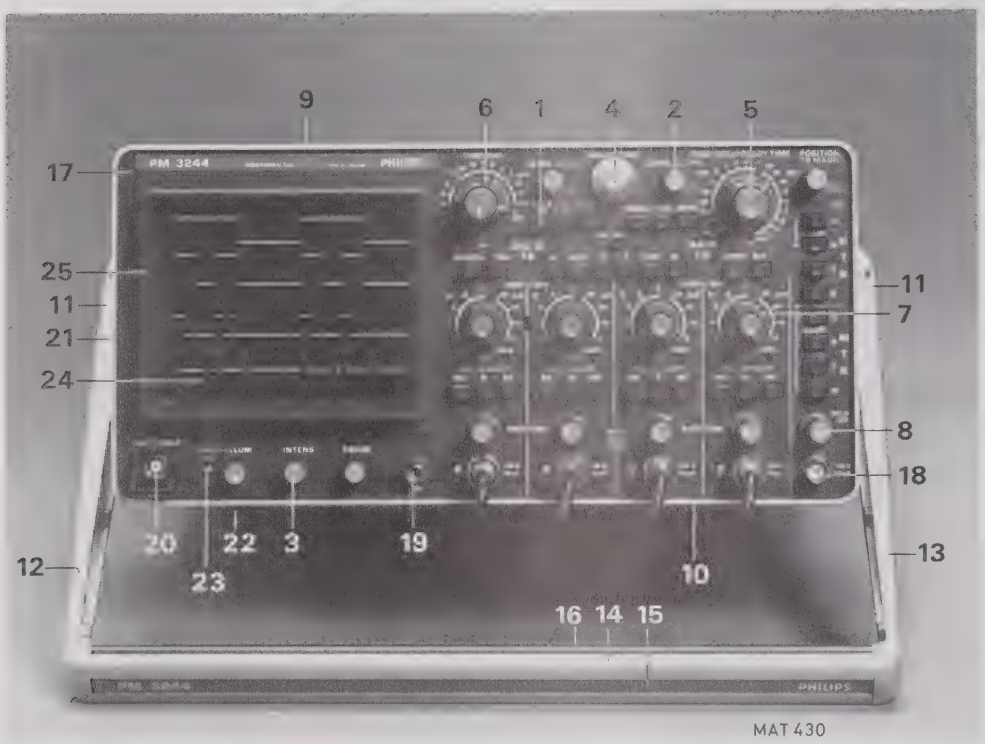

Fig. 3.14. Mechanical parts, front view

3.8.1. Mechanical parts front view

Item	*Ordering number*	*Description*
1	5322 414 14011	Knob for push-button switches
2	5322 414 31091	Knob, dia 10 mm
3	5322 414 31134	Knob, dia 10 mm (clamping)
	5322 492 64337	Clamping spring
	5322 414 74015	Cover, grey with dash
4	5322 414 34147	Ten turn dial
5	5322 414 34119	Knob, dia 14 mm, shaft 4 mm
	5322 414 74016	Cover, blue with dash
6	5322 414 34081	Knob, dia 24 mm, shaft 6 mm
7	5322 414 34079	Knob, dia 18,7 mm, shaft 6 mm
8	5322 414 31091	Knob, dia 10 mm
	5322 414 74028	Nutcover
	5322 414 74029	Cover, blue with dash
9	5322 447 94147	Upper cabinet plate
	5322 417 24024	Quick-fastener complete
10	5322 447 94146	Lower cabinet plate
11	5322 498 54082	Grip brackets left and right and grip bar
	5322 528 34113	Ratchet block (of bracket)
	5322 535 74401	Locking pin
	5322 492 54155	Spring

Item	*Ordering number*	*Description*
12	5322 498 54044	Bracket left hand side
13	5322 498 54043	Bracket right hand side
14	5322 498 54045	Grip
15	5322 455 84072	Text strip in grip bar
16	5322 498 54042	Plastic strip at the rear of the grip bar
17	5322 455 84064	Text plate
18	5322 267 10004	BNC socket
19	5322 535 80523	Earth socket
	5322 505 14178	Serrated nut for earth socket
20	5322 267 14014	Cal. socket (complete)
	5322 263 54003	BNC-cal. socket adapter
21	5322 447 94145	Aluminium side strip of cabinet
	4822 502 30047	Self tapping screw for side strip
22	5322 462 44297	Rubber foot (on lower cabinet plate)
23	5322 255 44088	Holder for LED
24	5322 480 34046	Contrast filter, grey
	5322 480 37074	Contrast filter, blue
25	5322 466 74059	Bezel

3.8.2. Mechanical parts rear view

Rear cabinet plate	5322 447 94148
Mains cable with plug	5322 321 14001
Fuse holder	5322 256 34081
Cable cleat	5322 325 60119
Earth terminal	5322 405 94046
Foot, complete	5322 462 44154

3.8.3. Mechanical parts top view

Cast aluminium front plate	5322 459 24071
Cast aluminium rear plate for PM 3244/00 .... PM 3244/04	5322 447 94144
Cast aluminium rear plate for PM 3244/05 and following	5322 447 94504
Clamping buffer for c.r.t. front	5322 381 14151
Socket for lamps (gratucule)	5322 255 24015
Mu-metal c.r.t. shield	5322 462 54138
Square nut in side strip (M3)	4822 505 10029
Rubber sleeve of c.r.t.	5322 532 74014
C.r.t. socket	5322 255 70159

Miscellaneous

Plastic spindle for R12 (power on)	5322 535 94656
Heatsink for TS604 and TS608 (final Y-amplifier)	5322 255 44031
Nut for knobs of attenuator	5322 505 14186
Tool for attenuator nuts (item 7)	5322 395 54023
Tool for time base switch nuts (item 6)	5322 395 54024
Nut for mounting the attenuator to the front	5322 505 14185

Front cover box

Front cover box, complete	5322 447 94169
Locking key	5322 535 94761
Inner plate	5322 459 84021
Spring	5322 492 34453
Circlip	4822 530 70126

3.8.4. Various mechanical parts

Switches

SK4	DTB TIME/DIV. switch	5322 273 64057
SK6	MTB TIME/DIV. switch	5322 273 54061
SK19	PULL TO INVERT switch	5322 273 44043
SK201	CHOPPER FREQUENCY switch	5322 277 24053

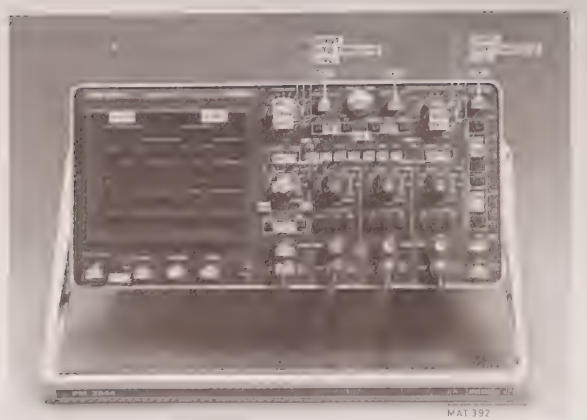

Fig. 3.15. Electrical item numbers, front panel.

Push button switches

Male clamping piece	5322 405 94074
Female clamping piece	5322 405 94075
Screw M3 x 20	5322 502 11142

			Sk8	Sk9	Sk10	Sk21	Sk11 ÷ Sk18	Sk22
Two-change over switch	5322 276 14101		3	2	4	4	4	4x3
Two-change over switch push on – push off (SK11 , ÷ SK18)	5322 276 14117						6	
Two-change over switch used as single shot switch	5322 276 14359			1				
Reset bar (for 6 switches)	5322 278 74007		1				1	4
Support for max. 11 switches (10 x 10,16 mm)	5322 466 85843		1		1			2
Support for max. 10 switches (7 x 10,16 mm) (2 x 25,4 mm)	5322 466 85839						1	

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fig. 3.14A

Note: the reset bar and the supports mentioned above must be sawn on the required size.

Coaxial cables

500 mm cable with plugs for PM 3244/00 ÷ PM 3244/04 — 5322 320 14027

For the PM3244/05 and following versions a new more reliable type of 50 ohm connector is used.

In future the units that are delivered by service also will be equipped with this new type of connector.

If such a unit is used in an instrument with old 50 ohm connectors the following parts are available to facilitate unit interconnection.

– The old 50 ohm coase connectors on the p.c.b. can be replaced by a new type.
  This new type consists of:
  socket 5322 268 24116
  contact pin 5322 268 14141

– Set with new coaxial cables 5322 320 14102
  The set contains:
  a) cables with one connector
     2 x 24 cm and 1 x 25 cm
  b) cables with a connector on each end
     2 x 29 cm, 1 x 30 cm, 1 x 50 cm and 1 x 65 cm

Multipole plugs and socket (Stocko)

3 pole plug (at cable)	4822 266 30071
3 pole socket (on p.c.b.)	4822 265 30121
4 pole plug	4822 266 30072
4 pole socket	4822 265 30119
5 pole plug	4822 266 30073
6 pole socket	4822 265 30117
7 pole plug	4822 266 40057
7 pole socket	4822 265 40119

3.8.5. Electrical parts

Capacitors

ITEM	ORDERING NUMBER	FARAD	TOL (%)	VOLTS	REMARKS
C 1	5322 122 14018	10PF	2		CERAMIC TUBULAR
C 2	5322 125 54003	60PF		300	TRIMMER
C 101	5322 125 64009	3PF		500	TRIMMER
C 102	5322 125 64015	4,5PF		500	TRIMMER
C 103	5322 123 34001	30PF	10	300	MICA
C 104	4822 121 40278	22NF	10	400	POLYESTER FOIL
C 105	4822 122 31047	5,6PF	0,25PF	100	CERAMIC PLATE
C 106	4822 122 31072	47PF	2	500	CERAMIC PLATE
C 107	5322 125 64012	1,5PF		400	TRIMMER
C 108	5322 125 64015	4,5PF		500	TRIMMER
C 109	5322 125 64009	3PF		500	TRIMMER
C 110	4822 122 31182	1PF	0,25PF	500	CERAMIC PLATE
C 111	5322 125 64015	4,5PF		500	TRIMMER
C 112	5322 123 10168	300PF	10	300	MICA
C 113	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 114	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 116	4822 122 31173	220PF	2	500	CERAMIC PLATE
C 117	4822 122 31047	5,6PF	0,25PF	100	CERAMIC PLATE
C 118	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 121	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 122	5322 125 50049	10PF		300	TRIMMER
C 123	4822 122 30027	1NF	-20+80	40	CERAMIC PLATE
C 128	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 129	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 130	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 200	4822 122 31116	2,2NF	10	100	CERAMIC PLATE
C 201	4822 122 30099	3,3NF	10	100	CERAMIC PLATE
C 202	4822 122 30034	470PF	10	100	CERAMIC PLATE
C 204	4822 122 31085	150PF	2	100	CERAMIC PLATE
C 205	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 206	4822 124 20687	15UF	-10+50	16	ELECTROLYTIC
C 207	4822 121 41161	100NF	10	250	POLYESTER FOIL
C 208	4822 121 41161	100NF	10	250	POLYESTER FOIL
C 209	4822 121 41161	100NF	10	250	POLYESTER FOIL
C 211	4822 121 41161	100NF	10	250	POLYESTER FOIL
C 212	4822 121 41161	100NF	10	250	POLYESTER FOIL
C 213	4822 121 41161	100NF	10	250	POLYESTER FOIL
C 214	4822 122 31173	220PF	2	100	CERAMIC PLATE
C 216	4822 122 31173	220PF	2	100	CERAMIC PLATE
C 217	4822 122 31173	220PF	2	100	CERAMIC PLATE
C 218	4822 122 31173	220PF	2	100	CERAMIC PLATE
C 376	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 377	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 379	4822 122 30048	1,8NF	10	100	CERAMIC PLATE
C 381	4822 122 31072	47PF	2	100	CERAMIC PLATE
C 382	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 401	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 402	4822 125 50045	22PF		250	TRIMMER
C 403	4822 122 31054	10PF	2	100	CERAMIC PLATE
C 404	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 405	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 406	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 407	4822 122 31054	10PF	2	100	CERAMIC PLATE
C 408	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 409	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 410	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 411	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 412	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 413	4822 122 31054	10PF	2	100	CERAMIC PLATE
C 414	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 415	4822 122 30091	390PF	2	100	CERAMIC PLATE
C 416	4822 125 50045	22PF		250	TRIMMER
C 417	4822 122 31061	18PF	2	100	CERAMIC PLATE
C 420	4822 122 31058	15PF	2	100	CERAMIC PLATE
C 423	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 424	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 425	4822 122 30099	3,3NF	10	100	CERAMIC PLATE
C 426	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE

ITEM	ORDERING NUMBER	FARAD	TOL (%)	VOLTS	REMARKS
C 427	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 428	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 429	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 432	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 501	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 504	4822 124 20687	15UF	-10+50	16	ELECTROLYTIC
C 506	4822 124 20687	15UF	-10+50	16	ELECTROLYTIC
C 507	4822 124 20687	15UF	-10+50	16	ELECTROLYTIC
C 508	4822 124 20687	15UF	-10+50	16	ELECTROLYTIC
C 509	4822 124 20687	15UF	-10+50	16	ELECTROLYTIC
C 511	4822 124 20687	15UF	-10+50	16	ELECTROLYTIC
C 514	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 516	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 517	4822 122 30045	27PF	2	100	CERAMIC PLATE
C 518	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 521	4822 122 31054	10PF	2	100	CERAMIC PLATE
C 522	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 523	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 524	4822 122 31063	22PF	2	100	CERAMIC PLATE
C 526	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 527	4822 122 31054	10PF	2	100	CERAMIC PLATE
C 531	4822 124 20687	15UF	-10+50	16	ELECTROLYTIC
C 532	4822 124 20687	15UF	-10+50	16	ELECTROLYTIC
C 533	4822 124 20687	15UF	-10+50	16	ELECTROLYTIC
C 534	4822 124 20687	15UF	-10+50	16	ELECTROLYTIC
C 536	4822 124 20687	15UF	-10+50	16	ELECTROLYTIC
C 537	4822 124 20687	15UF	-10+50	16	ELECTROLYTIC
C 601	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 602	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 603	4822 125 50045	22PF		250	TRIMMER
C 604	4822 122 31074	56PF	2	100	CERAMIC PLATE
C 605	4822 122 30045	27PF	2	100	CERAMIC PLATE
C 606	4822 125 50045	22PF		250	TRIMMER
C 607	4822 122 30103	22NF	-20+80	40	CERAMIC PLATE
C 608	4822 122 30027	1NF	10	100	CERAMIC PLATE
C 609	4822 122 31116	2,2NF	10	100	CERAMIC PLATE
C 614	4822 122 31054	10PF	2	100	CERAMIC PLATE
C 616	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 618	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 619	4822 122 31054	10PF	2	100	CERAMIC PLATE
C 621	4822 122 31054	10PF	2	100	CERAMIC PLATE
C 622	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 623	4822 121 41161	100NF	10	250	POLYESTER FOIL
C 624	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 626	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 627	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 628	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 629	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 631	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 632	4822 121 41161	100NF	10	250	POLYESTER FOIL
C 633	4822 122 31054	10PF	2	100	CERAMIC PLATE
C 634	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 651	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 652	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 653	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 701	4822 122 31202	33PF	2	500	CERAMIC PLATE
C 702	4822 122 30099	3,3NF	10	100	CERAMIC PLATE
C 703	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 704	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 705	4822 122 31195	10PF	2	500	CERAMIC PLATE
C 706	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 707	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 708	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 709	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 711	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 712	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 713	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 714	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 715	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 716	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE

ITEM	ORDERING NUMBER	FARAD	TOL (%)	VOLTS	REMARKS
C 717	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 751	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 752	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 761	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 762	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 771	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 772	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 781	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 782	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 791	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 792	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 801	4822 124 20687	15UF	-10+50	16	ELECTROLYTIC
C 802	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 803	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 804	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 805	4822 122 31036	2,2PF	0,25PF	100	CERAMIC PLATE
C 806	4822 124 20687	15UF	-10+50	16	ELECTROLYTIC
C 807	4822 124 20687	15UF	-10+50	16	ELECTROLYTIC
C 808	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 809	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 850	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 851	4822 124 20687	15UF	-10+50	16	ELECTROLYTIC
C 852	4822 124 20687	15UF	-10+50	16	ELECTROLYTIC
C 853	4822 124 20687	15UF	-10+50	16	ELECTROLYTIC
C 854	4822 124 20687	15UF	-10+50	16	ELECTROLYTIC
C 855	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 856	4822 122 31061	18PF	2	100	CERAMIC PLATE
C 857	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 858	4822 124 20707	6,8UF	-10+50	40	ELECTROLYTIC
C 859	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 860	4822 122 31047	5,6PF	0,25PF	100	CERAMIC PLATE
C 861	4822 122 31061	18PF	2	100	CERAMIC PLATE
C 862	4822 122 30114	2,2NF	10	100	CERAMIC PLATE
C 863	4822 124 20677	22UF	-10+50	10	ELECTROLYTIC
C 864	4822 124 20687	15UF	-10+50	16	ELECTROLYTIC
C 865	4822 122 30103	22NF	-20+80	40	CERAMIC PLATE
C 866	4822 121 50549	442PF	1	250	POLYSTYRENE FOIL
C 867	5322 121 40224	4,7UF	10	100	POLYESTER FOIL
C 868	4822 124 20687	15UF	-10+50	16	ELECTROLYTIC
C 869	5322 121 54108	47NF	1	63	POLYSTYRENE FOIL
C 871	5322 124 14158	330NF	10	50	ELECTROLYTIC TANTALUM
C 872	4822 122 30034	470PF	10	100	CERAMIC PLATE
C 873	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 874	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 876	4822 122 30103	22NF	-20+80	40	CERAMIC PLATE
C 878	4822 124 20687	15UF	-10+50	16	ELECTROLYTIC
C 879	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 881	4822 124 20687	15UF	-10+50	16	ELECTROLYTIC
C 882	4822 124 20687	15UF	-10+50	16	ELECTROLYTIC
C 1001	4822 124 20687	15UF	-10+50	16	ELECTROLYTIC
C 1002	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 1003	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 1004	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 1005	4822 122 31036	2,2PF	0,25PF	100	CERAMIC PLATE
C 1006	4822 124 20687	15UF	-10+50	16	ELECTROLYTIC
C 1007	4822 124 20687	15UF	-10+50	16	ELECTROLYTIC
C 1008	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 1009	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 1051	4822 124 20687	15UF	-10+50	16	ELECTROLYTIC
C 1052	4822 124 20687	15UF	-10+50	16	ELECTROLYTIC
C 1053	4822 124 20687	15UF	-10+50	16	ELECTROLYTIC
C 1054	4822 124 20687	15UF	-10+50	16	ELECTROLYTIC
C 1056	4822 122 31061	18PF	2	100	CERAMIC PLATE
C 1057	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 1058	4822 122 31061	18PF	2	100	CERAMIC PLATE
C 1059	5322 121 54076	453PF	1	250	POLYSTYRENE FOIL
C 1060	4822 122 31047	5,6PF	0,25PF	100	CERAMIC PLATE
C 1061	5322 121 54108	47NF	1	63	POLYSTYRENE FOIL
C 1062	4822 122 30034	470PF	10	100	CERAMIC PLATE
C 1063	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE

ITEM	ORDERING NUMBER	FARAD	TOL (%)	VOLTS	REMARKS
C 1064	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 1066	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 1067	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 1068	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 1069	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 1201	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 1202	4822 122 31215	0,68PF	0,25PF	100	CERAMIC PLATE
C 1203	4822 125 50077	5,5PF		250	TRIMMER
C 1204	4822 122 31116	2,2NF	10	500	CERAMIC PLATE
C 1205	4822 121 41161	100NF	10	250	POLYESTER FOIL
C 1206	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 1207	4822 121 41161	100NF	10	250	POLYESTER FOIL
C 1208	4822 125 50077	5,5PF		250	TRIMMER
C 1209	4822 122 31215	0,68PF	0,25PF	100	CERAMIC PLATE
C 1211	4822 122 31116	2,2NF	10	500	CERAMIC PLATE
C 1212	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 1213	4822 121 41161	100NF	10	250	POLYESTER FOIL
C 1214	4822 121 41161	100NF	10	250	POLYESTER FOIL
C 1216	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 1301	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 1302	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 1303	4822 122 30104	1PF	0,25PF	100	CERAMIC PLATE
C 1304	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 1306	4822 122 30054	1,2NF	10	100	CERAMIC PLATE
C 1307	4822 122 30098	3,9NF	10	100	CERAMIC PLATE
C 1308	5322 122 54004	470PF	20	4KV	CERAMIC DISK
C 1309	5322 122 54004	470PF	20	4KV	CERAMIC DISK
C 1310	4822 121 40406	15NF	10	250	POLYESTER FOIL
C 1311	4822 122 31081	100PF	2	100	CERAMIC PLATE
C 1312	5322 122 54006	3,3NF	-20+50	3K	CERAMIC DISK
C 1313	4822 121 41161	100NF	10	250	POLYESTER FOIL
C 1314	5322 122 54006	3,3NF	-20+50	3K	CERAMIC DISK
C 1316	4822 124 20468	33UF	-10+50	16	ELECTROLYTIC
C 1317	5322 121 40233	680NF	10	100	POLYESTER FOIL
C 1318	4822 121 50611	20NF	1	63	POLYSTYRENE FOIL
C 1319	4822 124 20468	33UF	-10+50	16	ELECTROLYTIC
C 1401	4822 124 20497	15UF	-10+50	63	ELECTROLYTIC
C 1402	4822 121 41161	100NF	10	250	POLYESTER FOIL
C 1403	4822 121 41161	100NF	10	250	POLYESTER FOIL
C 1404	4822 121 41161	100NF	10	250	POLYESTER FOIL
C 1406	5322 122 54006	3,3NF	-20+50	3K	CERAMIC DISK
C 1407	4822 121 40363	10NF	10	1600	POLYESTER FOIL
C 1416	5322 122 54004	470PF	20	4K	CERAMIC DISK
C 1417	5322 122 54004	470PF	20	4K	CERAMIC DISK
C 1418	5322 122 54004	470PF	20	4K	CERAMIC DISK
C 1419	5322 122 54004	470PF	20	4K	CERAMIC DISK
C 1421	5322 122 54004	470PF	20	4K	CERAMIC DISK
C 1804	5322 121 44142	220NF	10	250	POLYESTER FOIL
C 1806	4822 124 40066	2x50UF	-10+30	400	ELECTROLYTIC
C 1807	4822 124 20324	4UF	-10+30	400	ELECTROLYTIC
C 1808	4822 124 20324	4UF	-10+30	400	ELECTROLYTIC
C 1809	4822 124 20306	50UF	-10+30	100	ELECTROLYTIC
C 1810	4822 124 20681	220UF	-10+50	4	ELECTROLYTIC
C 1811	4822 121 40427	220NF	10	100	POLYESTER FOIL
C 1812	4822 124 20722	1UF	-10+50	63	ELECTROLYTIC
C 1814	4822 124 20484	15UF	-10+50	40	ELECTROLYTIC
C 1816	4822 124 20461	47UF	-10+50	10	ELECTROLYTIC
C 1817	4822 121 40443	680NF	10	100	POLYESTER FOIL
C 1818	4822 121 41161	100NF	10	250	POLYESTER FOIL
C 1819	4822 122 30099	3,3NF	10	100	CERAMIC PLATE
C 1821	4822 121 41161	22UF	-10+50	10	POLYESTER FOIL
C 1822	4822 121 41161	100NF	10	250	POLYESTER FOIL
C 1823	4822 124 20587	100UF	-10+50	25	ELECTROLYTIC
C 1824	4822 121 41169	220NF	10	250	POLYESTER FOIL
C 1826	4822 121 41161	100NF	10	250	POLYESTER FOIL
C 1827	4822 124 20457	470UF	-10+50	6,3	ELECTROLYTIC
C 1828	4822 121 41161	100NF	10	250	POLYESTER FOIL
C 1829	4822 121 41161	100NF	10	250	POLYESTER FOIL
C 1830	4822 121 40298	4,7NF	10	1600	POLYESTER FOIL
C 1831	4822 121 41161	100NF	10	250	POLYESTER FOIL
C 1832	4822 121 41161	100NF	10	250	POLYESTER FOIL
C 1833	4822 124 20497	15UF	-10+50	63	ELECTROLYTIC
C 1834	4822 124 20497	15UF	-10+50	63	ELECTROLYTIC
C 1836	4822 124 20469	68UF	-10+50	16	ELECTROLYTIC
C 1837	4822 124 20469	68UF	-10+50	16	ELECTROLYTIC

ITEM	ORDERING NUMBER	FARAD	TOL (%)	VOLTS	REMARKS
C 1838	4822 124 20469	68UF	-10+50	16	ELECTROLYTIC
C 1839	4822 124 20469	68UF	-10+50	16	ELECTROLYTIC
C 1841	4822 124 20454	150UF	-10+50	6,3	ELECTROLYTIC
C 1842	4822 124 20454	150UF	-10+50	6,3	ELECTROLYTIC
C 1843	4822 124 20454	150UF	-10+50	6,3	ELECTROLYTIC
C 1844	4822 124 20454	150UF	-10+50	6,3	ELECTROLYTIC
C 1846	4822 124 20454	150UF	-10+50	6,3	ELECTROLYTIC
C 1847	4822 124 20454	150UF	-10+50	6,3	ELECTROLYTIC
C 1848	4822 124 20454	150UF	-10+50	6,3	ELECTROLYTIC
C 1849	4822 124 20454	150UF	-10+50	6,3	ELECTROLYTIC
C 2376	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 2377	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 2379	4822 122 30048	1,8NF	10	100	CERAMIC PLATE
C 2381	4822 122 31072	47PF	2	100	CERAMIC PLATE
C 2382	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 2401	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 2402	4822 125 50045	22PF		250	TRIMMER
C 2403	4822 122 31054	10PF	2	100	CERAMIC PLATE
C 2404	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 2405	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 2406	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 2407	4822 122 31054	10PF	2	100	CERAMIC PLATE
C 2408	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 2409	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 2410	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 2411	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 2412	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 2413	4822 122 31054	10PF	2	100	CERAMIC PLATE
C 2414	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 2415	4822 122 30091	390PF	2	100	CERAMIC PLATE
C 2416	4822 125 50045	22PF		250	TRIMMER
C 2417	4822 122 31061	18PF	2	100	CERAMIC PLATE
C 2420	4822 122 31058	15PF	2	100	CERAMIC PLATE
C 2423	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 2424	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 2425	4822 122 30099	3,3NF	10	100	CERAMIC PLATE
C 2426	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 2427	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 2428	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 2429	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 2432	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 2576	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 2577	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 2579	4822 122 30048	1,8NF	10	100	CERAMIC PLATE
C 2580	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 2581	4822 122 31072	47PF	2	100	CERAMIC PLATE
C 2582	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 2601	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 2602	4822 125 50045	22PF		250	TRIMMER
C 2603	4822 122 31054	10PF	2	100	CERAMIC PLATE
C 2604	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 2605	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 2606	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 2607	4822 122 31054	10PF	2	100	CERAMIC PLATE
C 2608	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 2609	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 2610	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 2611	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 2612	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 2613	4822 122 31054	10PF	2	100	CERAMIC PLATE
C 2614	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 2615	4822 122 30091	390PF	2	100	CERAMIC PLATE
C 2616	4822 125 50045	22PF		250	TRIMMER
C 2617	4822 122 31061	18PF	2	100	CERAMIC PLATE
C 2620	4822 122 31058	15PF	2	100	CERAMIC PLATE
C 2623	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 2624	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 2625	4822 122 30099	3,3NF	10	100	CERAMIC PLATE
C 2626	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 2627	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE

ITEM	ORDERING NUMBER	FARAD	TOL (%)	VOLTS	REMARKS
C 2628	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 2629	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 2632	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 2776	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 2777	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 2779	4822 122 30048	1,8NF	10	100	CERAMIC PLATE
C 2781	4822 122 31072	47PF	2	100	CERAMIC PLATE
C 2782	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 2801	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 2802	4822 125 50045	22PF		250	TRIMMER
C 2803	4822 122 31054	10PF	2	100	CERAMIC PLATE
C 2804	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 2805	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 2806	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 2807	4822 122 31054	10PF	2	100	CERAMIC PLATE
C 2808	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 2809	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 2810	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 2811	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 2812	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 2813	4822 122 31054	10PF	2	100	CERAMIC PLATE
C 2814	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 2815	4822 122 30091	390PF	2	100	CERAMIC PLATE
C 2816	4822 125 50045	22PF		250	TRIMMER
C 2817	4822 122 31061	18PF	2	100	CERAMIC PLATE
C 2820	4822 122 31058	15PF	2	100	CERAMIC PLATE
C 2823	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 2824	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 2825	4822 122 30099	3,3NF	10	100	CERAMIC PLATE
C 2826	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 2827	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 2828	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 2829	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 2832	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE

Resistors

ITEM	ORDERING NUMBER	OHM	TOL (%)	TYPE	REMARKS
R 1	5322 101 44014	100K	20		CARBON POTM LIN + SWITCH
R 2	5322 103 54027	5K	5	2W	MULTITURN W-W POTENTIOMETER
R 3	5322 101 44014	100K	20		CARBON POTM LIN + SWITCH
R 4	5322 101 44015	50K	20		CARBON POTM LIN + SWITCH
R 5	5322 101 40041	4,7K	20	0.25W	CARBON POTM LIN + SWITCH
R 6	5322 101 40041	4,7K	20	0.25W	CARBON POTM LIN + SWITCH
R 7	5322 101 64027	10K	20	0.1W	CARBON POTM LIN + SWITCH
R 8	5322 101 24099	10K	20	0.1W	CARBON POTM LIN
R 9	5322 101 34016	47K	20	0.1W	CARBON POTM LOG
R 10	5322 101 24108	500		0.5W	CARBON POTM LIN
R 11	5322 101 24091	47K	20	0.1W	CARBON POTM LIN
R 12	5322 101 24055	25K	20		CARBON POTM LIN
R 13	5322 101 34018	4,7K	20	0.1W	CARBON POTM LOG
R 14	5322 101 24062	2,2M	20	0.1W	CARBON POTM LIN
R 101	5322 116 64048	56	5	0.125W	METAL OXIDE
R 102	5322 116 55218	920K	0,5	MR30	METAL FILM
R 103	5322 116 64052	39	5	0.125W	METAL OXIDE
R 104	5322 116 55067	88,9K	0,25	MR24C	METAL FILM
R 106	5322 116 64046	51	5	0.125W	METAL OXIDE
R 107	5322 116 55239	200K	0,5	MR25	METAL FILM
R 108	5322 116 64045	10	5	0.125W	METAL OXIDE
R 109	5322 116 64047	560	5	0.125W	METAL OXIDE
R 111	5322 116 64047	560	5	0.125W	METAL OXIDE
R 112	5322 116 64048	56	5	0.125W	METAL OXIDE
R 113	5322 116 55153	992K	0,5	SPEC	METAL FILM
R 114	5322 116 64049	47	5	0.125W	METAL OXIDE
R 116	5322 116 55066	8,08K	0,25	MR24C	METAL FILM
R 117	5322 116 64051	15	5	0.125W	METAL OXIDE
R 118	5322 116 64051	15	5	0.125W	METAL OXIDE
R 119	5322 111 30376	100M	5	0,125W	CARBON
R 120	4822 111 30324	100	5	CR16	CARBON
R 121	5322 116 50729	4,22K	1	MR25	METAL FILM
R 122	5322 116 54012	6,81K	1	MR25	METAL FILM
R 123	5322 116 54519	402	1	MR25	METAL FILM
R 124	5322 116 54208	210K	1	MR25	METAL FILM
R 126	5322 116 54774	590K	1	MR30	METAL FILM
R 127	5322 116 54038	221K	1	MR25	METAL FILM
R 128	4822 110 42214	10M	5	VR37	CARBON
R 129	5322 100 10143	1K	20	0.75W	TRIMMING POTM
R 131	5322 116 54208	210K	1	MR25	METAL FILM
R 132	5322 100 10141	10K	20	0.75W	TRIMMING POTM
R 133	5322 116 54689	82,5K	1	MR25	METAL FILM
R 134	4822 110 42227	33M	5	VR37	CARBON
R 139	5322 116 50672	51,1K	1	MR25	METAL FILM
R 140	4822 110 63047	5,6	5	CR25	CARBON
R 141	5322 100 10141	10K	20	0.75W	TRIMMING POTM
R 148	5322 116 50592	442	1	MR25	METAL FILM
R 149	5322 116 50592	442	1	MR25	METAL FILM
R 201	5322 116 54466	90,9	1	MR25	METAL FILM
R 202	5322 116 54466	90,9	1	MR25	METAL FILM
R 203	5322 116 54571	1,96K	1	MR25	METAL FILM
R 204	5322 116 50417	162	1	MR25	METAL FILM
R 208	5322 116 50414	2,87K	1	MR25	METAL FILM
R 209	5322 116 50586	1,54K	1	MR25	METAL FILM
R 211	5322 116 50675	2,26K	1	MR25	METAL FILM
R 212	5322 116 50568	4,99	1	MR25	METAL FILM
R 213	5322 116 54012	6,81K	1	MR25	METAL FILM
R 214	5322 116 54012	6,81K	1	MR25	METAL FILM
R 216	5322 116 54012	6,81K	1	MR25	METAL FILM
R 217	5322 116 54012	6,81K	1	MR25	METAL FILM
R 218	5322 116 50481	22,6K	1	MR25	METAL FILM
R 219	5322 116 50556	4,42K	1	MR25	METAL FILM
R 221	5322 116 50481	22,6K	1	MR25	METAL FILM
R 222	5322 116 50556	4,42K	1	MR25	METAL FILM
R 223	5322 116 50481	22,6K	1	MR25	METAL FILM
R 224	5322 116 50556	4,42K	1	MR25	METAL FILM
R 226	5322 116 50481	22,6K	1	MR25	METAL FILM
R 227	5322 116 50556	4,42K	1	MR25	METAL FILM

ITEM	ORDERING NUMBER	OHM	TOL (%)	TYPE	REMARKS
R 228	5322 116 50481	22,6K	1	MR25	METAL FILM
R 229	5322 116 50556	4,42K	1	MR25	METAL FILM
R 231	5322 116 54012	6,81K	1	MR25	METAL FILM
R 232	5322 116 54619	10K	1	MR25	METAL FILM
R 233	5322 116 50664	2,05K	1	MR25	METAL FILM
R 234	5322 116 50664	2,05K	1	MR25	METAL FILM
R 236	5322 116 50664	2,05K	1	MR25	METAL FILM
R 237	5322 116 50664	2,05K	1	MR25	METAL FILM
R 238	5322 116 50664	2,05K	1	MR25	METAL FILM
R 239	5322 116 50664	2,05K	1	MR25	METAL FILM
R 241	5322 116 50556	4,42K	1	MR25	METAL FILM
R 242	5322 116 54012	6,81K	1	MR25	METAL FILM
R 376	5322 116 54012	6,81K	1	MR25	METAL FILM
R 377	5322 116 54595	5,11K	1	MR25	METAL FILM
R 378	5322 116 50558	18,7K	1	MR25	METAL FILM
R 379	5322 101 14048	47K	20	0,5W	TRIMMING POTM
R 381	5322 116 50527	33,2	1	MR25	METAL FILM
R 382	4822 111 30067	33	5	CR16	CARBON
R 383	5322 116 54557	1,21K	1	MR25	METAL FILM
R 387	5322 116 50452	10	1	MR25	METAL FILM
R 388	5322 116 54519	402	1	MR25	METAL FILM
R 389	5322 116 54469	100	1	MR25	METAL FILM
R 390	5322 116 54541	825	1	MR25	METAL FILM
R 391	5322 116 50568	4,99	1	MR25	METAL FILM
R 392	5322 116 50527	33,2	1	MR25	METAL FILM
R 393	4822 111 30324	100	5	CR16	CARBON
R 394	5322 116 54439	35,7	1	MR25	METAL FILM
R 396	5322 116 54548	976	1	MR25	METAL FILM
R 397	5322 116 54439	35,7	1	MR25	METAL FILM
R 398	4822 111 30324	100	5	CR16	CARBON
R 401	5322 116 50524	3,01K	1	MR25	METAL FILM
R 402	5322 116 54508	301	1	MR25	METAL FILM
R 403	4822 111 30067	33	5	CR16	CARBON
R 404	5322 116 50524	3,01K	1	MR25	METAL FILM
R 405	5322 116 54464	86,6	1	MR25	METAL FILM
R 406	4822 111 30347	10	5	CR16	CARBON
R 407	5322 116 50492	46,4	1	MR25	METAL FILM
R 408	5322 116 50568	4,99	1	MR25	METAL FILM
R 409	5322 116 50492	46,4	1	MR25	METAL FILM
R 410	5322 116 34036	47	5	0.5W	NTC
R 411	4822 111 30347	10	5	CR16	CARBON
R 412	4822 111 30067	33	5	CR16	CARBON
R 413	5322 116 50515	1,78K	1	MR25	METAL FILM
R 414	5322 116 54005	3,32K	1	MR25	METAL FILM
R 416	5322 116 50452	10	1	MR25	METAL FILM
R 417	5322 116 50571	715	1	MR25	METAL FILM
R 418	4822 111 30245	47	5	CR16	CARBON
R 419	4822 111 30347	10	5	CR16	CARBON
R 420	5322 116 54464	86,6	1	MR25	METAL FILM
R 421	4822 111 30067	33	5	CR16	CARBON
R 422	5322 116 54492	178	1	MR25	METAL FILM
R 423	4822 111 30067	33	5	CR16	CARBON
R 424	5322 116 54576	2,37K	1	MR25	METAL FILM
R 426	5322 116 54587	3,65K	1	MR25	METAL FILM
R 427	5322 116 50527	33,2	1	MR25	METAL FILM
R 428	4822 111 30067	33	5	CR16	CARBON
R 429	5322 116 54492	178	1	MR25	METAL FILM
R 431	4822 111 30347	10	5	CR16	CARBON
R 432	5322 116 50571	715	1	MR25	METAL FILM
R 433	4822 111 30245	47	5	CR16	CARBON
R 434	5322 116 50452	10	1	MR25	METAL FILM
R 436	4822 111 30067	33	5	CR16	CARBON
R 437	5322 116 54613	8,66K	1	MR25	METAL FILM
R 438	5322 116 54005	3,32K	1	MR25	METAL FILM
R 439	4822 111 30067	33	5	CR16	CARBON
R 440	5322 116 54581	2,94K	1	MR25	METAL FILM
R 441	5322 116 50926	40,2	1	MR25	METAL FILM
R 442	5322 100 10112	1K	20	0,5W	TRIMMING POTM
R 443	5322 116 54515	348	1	MR25	METAL FILM
R 444	5322 116 50926	40,2	1	MR25	METAL FILM

ITEM	ORDERING NUMBER	OHM	TOL (%)	TYPE	REMARKS
R 445	5322 116 54595	5,11K	1	MR25	METAL FILM
R 446	4822 111 30067	33	5	CR16	CARBON
R 447	5322 116 50442	48,7K	1	MR25	METAL FILM
R 448	5322 100 10113	10K	20	0,5W	TRIMMING POTM
R 461	5322 116 54005	3,32K	1	MR25	METAL FILM
R 463	5322 116 54576	2,37K	1	MR25	METAL FILM
R 464	5322 116 54005	3,32K	1	MR25	METAL FILM
R 465	5322 116 54012	6,81K	1	MR25	METAL FILM
R 466	5322 116 54585	3,48K	1	MR25	METAL FILM
R 467	4822 111 30067	33	5	CR16	CARBON
R 468	4822 111 30067	33	5	CR16	CARBON
R 469	4822 111 30067	33	5	CR16	CARBON
R 471	4822 111 30067	33	5	CR16	CARBON
R 472	4822 111 30067	33	5	CR16	CARBON
R 473	4822 111 30067	33	5	CR16	CARBON
R 474	4822 111 30067	33	5	CR16	CARBON
R 476	4822 111 30067	33	5	CR16	CARBON
R 477	4822 111 30067	33	5	CR16	CARBON
R 478	5322 116 54469	100	1	MR25	METAL FILM
R 479	5322 116 50621	536	1	MR25	METAL FILM
R 481	4822 111 30067	33	5	CR16	CARBON
R 482	5322 116 54469	100	1	MR25	METAL FILM
R 483	4822 111 30067	33	5	CR16	CARBON
R 484	5322 116 54613	8,66K	1	MR25	METAL FILM
R 486	5322 116 50524	3,01K	1	MR25	METAL FILM
R 487	5322 116 50527	33,2	1	MR25	METAL FILM
R 488	5322 116 54469	100	1	MR25	METAL FILM
R 500	5322 116 54469	100	1	MR25	METAL FILM
R 501	5322 116 54525	511	1	MR25	METAL FILM
R 502	5322 116 54549	1K	1	MR25	METAL FILM
R 503	5322 116 50452	10	1	MR25	METAL FILM
R 504	5322 116 50511	48,7	1	MR25	METAL FILM
R 505	5322 116 54469	100	1	MR25	METAL FILM
R 506	5322 116 54549	1K	1	MR25	METAL FILM
R 507	5322 116 54525	511	1	MR25	METAL FILM
R 511	5322 116 54258	9,53	1	MR25	METAL FILM
R 512	5322 116 50568	4,99	1	MR25	METAL FILM
R 513	5322 116 54258	9,53	1	MR25	METAL FILM
R 514	5322 116 50568	4,99	1	MR25	METAL FILM
R 516	5322 116 54258	9,53	1	MR25	METAL FILM
R 517	5322 116 54258	9,53	1	MR25	METAL FILM
R 520	5322 116 54469	100	1	MR25	METAL FILM
R 521	5322 116 54525	511	1	MR25	METAL FILM
R 522	5322 116 54549	1K	1	MR25	METAL FILM
R 523	5322 116 50452	10	1	MR25	METAL FILM
R 524	5322 116 50511	48,7	1	MR25	METAL FILM
R 525	5322 116 54469	100	1	MR25	METAL FILM
R 526	5322 116 54549	1K	1	MR25	METAL FILM
R 527	5322 116 54525	511	1	MR25	METAL FILM
R 528	5322 116 50524	3,01K	1	MR25	METAL FILM
R 529	5322 116 54621	10,2K	1	MR25	METAL FILM
R 531	5322 101 14048	47K	20	0,5W	TRIMMING POTM
R 532	5322 116 50527	33,2	1	MR25	METAL FILM
R 533	5322 116 54643	20,5K	1	MR25	METAL FILM
R 534	5322 111 44156	510	5	CR16	CARBON
R 536	4822 111 30067	33	5	CR16	CARBON
R 537	5322 116 55273	196	1	MR25	METAL FILM
R 538	5322 116 50555	1,27K	1	MR25	METAL FILM
R 539	5322 116 50568	4,99	1	MR25	METAL FILM
R 541	5322 116 55273	196	1	MR25	METAL FILM
R 542	5322 116 54519	402	1	MR25	METAL FILM
R 543	5322 116 50593	16,2K	1	MR25	METAL FILM
R 544	5322 116 50452	10	1	MR25	METAL FILM
R 546	5322 111 44156	510	5	CR16	CARBON
R 547	5322 116 54541	825	1	MR25	METAL FILM
R 548	5322 101 14069	22K	20	0.5W	TRIMMING POTM
R 549	5322 116 54595	5,11K	1	MR25	METAL FILM
R 551	4822 111 30245	47	5	CR16	CARBON
R 552	5322 116 50452	10	1	MR25	METAL FILM
R 553	4822 111 30067	33	5	CR16	CARBON

ITEM	ORDERING NUMBER	OHM	TOL (%)	TYPE	REMARKS
R 554	5322 116 50506	154	1	MR25	METAL FILM
R 556	5322 116 50568	4,99	1	MR25	METAL FILM
R 557	5322 116 50511	48,7	1	MR25	METAL FILM
R 558	5322 116 54561	1,33K	1	MR25	METAL FILM
R 559	5322 116 50569	95,3	1	MR25	METAL FILM
R 560	4822 111 30324	100	5	CR16	CARBON
R 561	5322 116 50506	154	1	MR25	METAL FILM
R 562	5322 116 50511	48,7	1	MR25	METAL FILM
R 563	5322 116 54561	1,33K	1	MR25	METAL FILM
R 564	4822 111 30067	33	5	CR16	CARBON
R 566	5322 116 50452	10	1	MR25	METAL FILM
R 567	4822 111 30067	33	5	CR16	CARBON
R 568	4822 111 30245	47	5	CR16	CARBON
R 569	5322 116 50568	4,99	1	MR25	METAL FILM
R 571	5322 116 54005	3,32K	1	MR25	METAL FILM
R 572	5322 116 54258	9,53	1	MR25	METAL FILM
R 573	5322 116 50568	4,99	1	MR25	METAL FILM
R 574	5322 116 54258	9,53	1	MR25	METAL FILM
R 576	5322 116 50568	4,99	1	MR25	METAL FILM
R 577	5322 116 54258	9,53	1	MR25	METAL FILM
R 578	5322 116 54258	9,53	1	MR25	METAL FILM
R 579	5322 116 50568	4,99	1	MR25	METAL FILM
R 581	5322 116 50568	4,99	1	MR25	METAL FILM
R 601	5322 116 50926	40,2	1	MR25	METAL FILM
R 602	5322 116 54506	287	1	MR25	METAL FILM
R 603	4822 111 30067	33	5	CR16	CARBON
R 604	5322 116 54492	178	1	MR25	METAL FILM
R 606	5322 116 55273	196	1	MR25	METAL FILM
R 607	5322 116 54519	402	1	MR25	METAL FILM
R 608	4822 111 30067	33	5	CR16	CARBON
R 609	5322 116 54492	178	1	MR25	METAL FILM
R 610	5322 116 50524	3,01K	1	MR25	METAL FILM
R 611	5322 116 50926	40,2	1	MR25	METAL FILM
R 612	5322 116 54506	287	1	MR25	METAL FILM
R 613	5322 116 50506	154	1	MR25	METAL FILM
R 614	4822 111 30067	33	5	CR16	CARBON
R 615	5322 116 50524	3,01K	1	MR25	METAL FILM
R 616	5322 116 54444	53,6	1	MR25	METAL FILM
R 617	4822 111 30067	33	5	CR16	CARBON
R 618	5322 116 54444	53,6	1	MR25	METAL FILM
R 619	5322 101 14009	220	20	0,5W	TRIMMING POTM
R 621	5322 100 10114	4,7K	20	0.5W	TRIMMING POTM
R 622	5322 100 10113	10K	20	0,5W	TRIMMING POTM
R 623	5322 116 54613	8,66K	1	MR25	METAL FILM
R 624	5322 116 54619	10K	1	MR25	METAL FILM
R 627	4822 111 30245	47	5	CR16	CARBON
R 628	4822 111 30067	33	5	CR16	CARBON
R 629	5322 116 54608	7,5K	1	MR25	METAL FILM
R 630	4822 111 30067	33	5	CR16	CARBON
R 631	5322 116 50556	4,42K	1	MR25	METAL FILM
R 632	4822 111 30245	47	5	CR16	CARBON
R 633	4822 111 30067	33	5	CR16	CARBON
R 634	4822 111 30067	33	5	CR16	CARBON
R 636	4822 111 30067	33	5	CR16	CARBON
R 637	5322 116 50457	215	1	MR25	METAL FILM
R 638	5322 116 50669	205	1	MR25	METAL FILM
R 639	5322 116 54451	61,9	1	MR25	METAL FILM
R 641	5322 101 14047	470	20	0,5W	TRIMMING POTM
R 642	5322 116 50457	215	1	MR25	METAL FILM
R 644	5322 116 50669	205	1	MR25	METAL FILM
R 646	5322 116 54451	61,9	1	MR25	METAL FILM
R 647	4822 111 30067	33	5	CR16	CARBON
R 648	4822 111 30245	47	5	CR16	CARBON
R 649	5322 116 50515	1,78K	1	MR25	METAL FILM
R 650	5322 116 55277	9,09K	1	MR25	METAL FILM
R 651	5322 116 54585	3,48K	1	MR25	METAL FILM
R 652	5322 116 50474	42,2K	1	MR25	METAL FILM
R 653	5322 116 50417	162	1	MR25	METAL FILM
R 654	5322 116 54011	5,62K	1	MR25	METAL FILM
R 655	5322 116 50904	30,1	1	MR25	METAL FILM

ITEM	ORDERING NUMBER	OHM	TOL (%)	TYPE	REMARKS
R 656	5322 116 54557	1,21K	1	MR25	METAL FILM
R 657	5322 116 50579	3,16K	1	MR25	METAL FILM
R 658	5322 116 54516	365	1	MR25	METAL FILM
R 659	4822 111 30067	33	5	CR16	CARBON
R 660	5322 116 54516	365	1	MR25	METAL FILM
R 661	5322 116 50509	4,87K	1	MR25	METAL FILM
R 662	5322 116 50579	3,16K	1	MR25	METAL FILM
R 663	5322 116 54012	6,81K	1	MR25	METAL FILM
R 664	5322 116 54557	1,21K	1	MR25	METAL FILM
R 665	5322 116 55277	9,09K	1	MR25	METAL FILM
R 666	5322 116 54011	5,62K	1	MR25	METAL FILM
R 667	4822 111 30245	47	5	CR16	CARBON
R 668	5322 116 50515	1,78K	1	MR25	METAL FILM
R 669	5322 116 54585	3,48K	1	MR25	METAL FILM
R 671	5322 116 50474	42,2K	1	MR25	METAL FILM
R 672	5322 116 50417	162	1	MR25	METAL FILM
R 681	5322 116 50568	4,99	1	MR25	METAL FILM
R 682	5322 116 50568	4,99	1	MR25	METAL FILM
R 683	5322 116 50568	4,99	1	MR25	METAL FILM
R 684	5322 101 20408	100K	20	0.1W	CARBON POTM LIN
R 700	5322 116 50527	33,2	1	MR25	METAL FILM
R 701	5322 116 54743	301K	1	MR25	METAL FILM
R 702	5322 116 54038	221K	1	MR25	METAL FILM
R 703	5322 116 54595	5,11K	1	MR25	METAL FILM
R 704	5322 116 54263	681K	1	MR30	METAL FILM
R 705	5322 101 14051	220	20	0.5W	TRIMMING POTM
R 706	5322 116 50452	10	1	MR25	METAL FILM
R 707	5322 116 50452	10	1	MR25	METAL FILM
R 708	5322 116 54005	3,32K	1	MR25	METAL FILM
R 709	5322 116 50452	10	1	MR25	METAL FILM
R 711	5322 116 54676	56,2K	1	MR25	METAL FILM
R 712	5322 116 50527	33,2	1	MR25	METAL FILM
R 713	5322 116 54585	3,48K	1	MR25	METAL FILM
R 714	5322 116 54549	1K	1	MR25	METAL FILM
R 716	5322 116 50527	33,2	1	MR25	METAL FILM
R 717	5322 116 54587	3,65K	1	MR25	METAL FILM
R 718	5322 116 50515	1,78K	1	MR25	METAL FILM
R 719	5322 116 54469	100	1	MR25	METAL FILM
R 720	5322 116 54525	511	1	MR25	METAL FILM
R 721	5322 116 50664	2,05K	1	MR25	METAL FILM
R 722	5322 116 54536	750	1	MR25	METAL FILM
R 723	5322 116 50452	10	1	MR25	METAL FILM
R 724	5322 116 50527	33,2	1	MR25	METAL FILM
R 725	5322 116 50954	38,3	1	MR25	METAL FILM
R 726	5322 116 50527	33,2	1	MR25	METAL FILM
R 727	5322 116 50571	715	1	MR25	METAL FILM
R 728	5322 116 50636	2,74K	1	MR25	METAL FILM
R 729	5322 116 50452	10	1	MR25	METAL FILM
R 731	5322 116 54525	511	1	MR25	METAL FILM
R 732	5322 116 50664	2,05K	1	MR25	METAL FILM
R 733	5322 116 54536	750	1	MR25	METAL FILM
R 734	5322 116 50452	10	1	MR25	METAL FILM
R 735	5322 116 50635	1,47K	1	MR25	METAL FILM
R 736	5322 116 50527	33,2	1	MR25	METAL FILM
R 737	5322 116 50527	33,2	1	MR25	METAL FILM
R 738	5322 116 50571	715	1	MR25	METAL FILM
R 739	5322 116 50636	2,74K	1	MR25	METAL FILM
R 740	5322 116 50954	38,3	1	MR25	METAL FILM
R 741	5322 116 50452	10	1	MR25	METAL FILM
R 742	5322 116 50452	10	1	MR25	METAL FILM
R 743	5322 116 50452	10	1	MR25	METAL FILM
R 751	5322 116 54469	100	1	MR25	METAL FILM
R 752	5322 116 50452	10	1	MR25	METAL FILM
R 753	5322 116 54554	1,1K	1	MR25	METAL FILM
R 754	5322 116 54469	100	1	MR25	METAL FILM
R 756	5322 116 50452	10	1	MR25	METAL FILM
R 757	5322 116 54554	1,1K	1	MR25	METAL FILM
R 761	5322 116 54469	100	1	MR25	METAL FILM
R 762	5322 116 50452	10	1	MR25	METAL FILM
R 763	5322 116 54554	1,1K	1	MR25	METAL FILM

ITEM	ORDERING NUMBER	OHM	TOL (%)	TYPE	REMARKS
R 764	5322 116 54469	100	1	MR25	METAL FILM
R 766	5322 116 50452	10	1	MR25	METAL FILM
R 767	5322 116 54554	1,1K	1	MR25	METAL FILM
R 771	5322 116 54469	100	1	MR25	METAL FILM
R 772	5322 116 50452	10	1	MR25	METAL FILM
R 773	5322 116 54554	1,1K	1	MR25	METAL FILM
R 774	5322 116 54469	100	1	MR25	METAL FILM
R 776	5322 116 50452	10	1	MR25	METAL FILM
R 777	5322 116 54554	1,1K	1	MR25	METAL FILM
R 781	5322 116 54469	100	1	MR25	METAL FILM
R 782	5322 116 50452	10	1	MR25	METAL FILM
R 783	5322 116 54554	1,1K	1	MR25	METAL FILM
R 784	5322 116 54469	100	1	MR25	METAL FILM
R 786	5322 116 50452	10	1	MR25	METAL FILM
R 787	5322 116 54554	1,1K	1	MR25	METAL FILM
R 791	5322 116 54469	100	1	MR25	METAL FILM
R 792	5322 116 50452	10	1	MR25	METAL FILM
R 793	5322 116 54554	1,1K	1	MR25	METAL FILM
R 794	5322 116 54469	100	1	MR25	METAL FILM
R 796	5322 116 50452	10	1	MR25	METAL FILM
R 797	5322 116 54554	1,1K	1	MR25	METAL FILM
R 801	4822 111 30324	100	5	CR16	CARBON
R 802	5322 111 30396	22	5	CR16	CARBON
R 803	5322 116 54012	6,81K	1	MR25	METAL FILM
R 804	4822 111 30263	3,3K	5	CR16	CARBON
R 806	5322 116 50586	1,54K	1	MR25	METAL FILM
R 807	5322 116 50895	18,7	1	MR25	METAL FILM
R 808	5322 116 50895	18,7	1	MR25	METAL FILM
R 809	5322 111 30396	22	5	CR16	CARBON
R 811	5322 116 54012	6,81K	1	MR25	METAL FILM
R 812	5322 116 54525	511	1	MR25	METAL FILM
R 813	5322 111 30396	22	5	CR16	CARBON
R 814	5322 116 54592	4,02K	1	MR25	METAL FILM
R 816	5322 111 30396	22	5	CR16	CARBON
R 817	5322 116 50415	1,15K	1	MR25	METAL FILM
R 818	5322 116 50415	1,15K	1	MR25	METAL FILM
R 819	5322 111 30396	22	5	CR16	CARBON
R 821	4822 110 63054	10	5	CR25	CARBON
R 822	5322 116 54683	68,1K	1	MR25	METAL FILM
R 823	5322 116 50636	2,74K	1	MR25	METAL FILM
R 824	5322 116 54683	68,1K	1	MR25	METAL FILM
R 826	5322 116 54552	1,05K	1	MR25	METAL FILM
R 827	5322 116 50635	1,47K	1	MR25	METAL FILM
R 828	5322 116 50635	1,47K	1	MR25	METAL FILM
R 829	5322 116 54552	1,05K	1	MR25	METAL FILM
R 831	5322 111 30396	22	5	CR16	CARBON
R 832	5322 111 30396	22	5	CR16	CARBON
R 833	5322 116 50527	33,2	1	MR25	METAL FILM
R 834	5322 116 50506	154	1	MR25	METAL FILM
R 836	5322 116 54508	301	1	MR25	METAL FILM
R 837	5322 116 54552	1,05K	1	MR25	METAL FILM
R 838	5322 111 30396	22	5	CR16	CARBON
R 839	5322 116 54552	1,05K	1	MR25	METAL FILM
R 840	4822 111 30067	33	5	CR16	CARBON
R 841	5322 116 54576	2,37K	1	MR25	METAL FILM
R 842	5322 116 54519	402	1	MR25	METAL FILM
R 843	4822 110 63054	10	5	CR25	CARBON
R 844	4822 110 63054	10	5	CR25	CARBON
R 851	4822 110 63036	2,2	5	CR25	CARBON
R 852	4822 110 63036	2,2	5	CR25	CARBON
R 853	4822 110 63036	2,2	5	CR25	CARBON
R 854	4822 110 63036	2,2	5	CR25	CARBON
R 856	5322 116 54564	1,5K	1	MR25	METAL FILM
R 857	5322 111 44156	510	5	CR16	CARBON
R 858	5322 116 54549	1K	1	MR25	METAL FILM
R 859	5322 116 54619	10K	1	MR25	METAL FILM
R 861	5322 116 54629	14K	1	MR25	METAL FILM
R 862	5322 111 34094	620	5	CR16	CARBON
R 863	4822 111 30303	8,2K	5	CR16	CARBON
R 864	4822 111 30119	3K	5	CR16	CARBON

ITEM	ORDERING NUMBER	OHM	TOL (%)	TYPE	REMARKS
R 867	5322 116 50561	590	1	MR25	METAL FILM
R 868	5322 116 54011	5,62K	1	MR25	METAL FILM
R 869	5322 116 54585	3,48K	1	MR25	METAL FILM
R 871	5322 111 44153	15	5	CR16	CARBON
R 872	5322 116 54474	110	1	MR25	METAL FILM
R 873	5322 101 14069	22K	20	0.5W	TRIMMING POTM
R 874	5322 116 54643	20,5K	1	MR25	METAL FILM
R 876	5322 116 54619	10K	1	MR25	METAL FILM
R 877	5322 116 54597	5,36K	1	MR25	METAL FILM
R 878	5322 116 50415	1,15K	1	MR25	METAL FILM
R 879	5322 116 54481	130	1	MR25	METAL FILM
R 880	5322 116 54585	3,48K	1	MR25	METAL FILM
R 881	5322 116 55273	196	1	MR25	METAL FILM
R 882	5322 116 54696	100K	1	MR25	METAL FILM
R 883	5322 116 54632	14,7K	1	MR25	METAL FILM
R 884	5322 116 54632	14,7K	1	MR25	METAL FILM
R 885	5322 116 50583	5,9K	1	MR25	METAL FILM
R 886	5322 116 50481	22,6K	1	MR25	METAL FILM
R 887	5322 116 50459	422	1	MR25	METAL FILM
R 888	5322 116 54005	3,32K	1	MR25	METAL FILM
R 889	5322 116 54012	6,81K	1	MR25	METAL FILM
R 890	5322 116 50527	33,2	1	MR25	METAL FILM
R 891	5322 116 50675	2,26K	1	MR25	METAL FILM
R 892	5322 116 54619	10K	1	MR25	METAL FILM
R 893	4822 111 30067	33	5	CR16	CARBON
R 894	5322 116 50509	4,87K	1	MR25	METAL FILM
R 895	5322 116 50586	1,54K	1	MR25	METAL FILM
R 896	5322 116 50636	2,74K	1	MR25	METAL FILM
R 897	5322 116 54519	402	1	MR25	METAL FILM
R 898	5322 116 54534	681	1	MR25	METAL FILM
R 899	5322 116 50452	10	1	MR25	METAL FILM
R 900	4822 111 30067	33	5	CR16	CARBON
R 901	5322 116 54549	1K	1	MR25	METAL FILM
R 902	4822 111 30067	33	5	CR16	CARBON
R 903	5322 116 50527	33,2	1	MR25	METAL FILM
R 904	5322 116 50636	2,74K	1	MR25	METAL FILM
R 905	5322 116 54587	3,65K	1	MR25	METAL FILM
R 906	5322 111 30396	22	5	CR16	CARBON
R 907	5322 116 50556	4,42K	1	MR25	METAL FILM
R 908	4822 111 30067	33	5	CR16	CARBON
R 909	5322 116 55236	898	0,5	MR25	METAL FILM
R 910	5322 116 54549	1K	1	MR25	METAL FILM
R 911	5322 116 50579	3,16K	1	MR25	METAL FILM
R 912	5322 116 50556	4,42K	1	MR25	METAL FILM
R 913	5322 116 50664	2,05K	1	MR25	METAL FILM
R 914	5322 100 10114	4,7K	20	0.5W	TRIMMING POTM
R 915	5322 116 54624	11,5K	1	MR25	METAL FILM
R 916	5322 116 50481	22,6K	1	MR25	METAL FILM
R 917	5322 116 54549	1K	1	MR25	METAL FILM
R 918	5322 116 54549	1K	1	MR25	METAL FILM
R 919	5322 116 50559	27,4K	1	MR25	METAL FILM
R 920	5322 116 54466	90,9	1	MR25	METAL FILM
R 921	5322 116 50559	27,4K	1	MR25	METAL FILM
R 922	5322 116 50556	4,42K	1	MR25	METAL FILM
R 923	5322 116 50556	4,42K	1	MR25	METAL FILM
R 925	5322 116 54619	10K	1	MR25	METAL FILM
R 926	5322 116 54011	5,62K	1	MR25	METAL FILM
R 927	5322 116 54011	5,62K	1	MR25	METAL FILM
R 928	5322 111 30396	22	5	CR16	CARBON
R 929	5322 116 55276	13,3K	1	MR25	METAL FILM
R 931	4822 111 30352	82	5	CR16	CARBON
R 932	4822 111 30245	47	5	CR16	CARBON
R 933	5322 111 30396	22	5	CR16	CARBON
R 934	5322 111 30279	33K	5	CR16	CARBON
R 936	5322 116 54565	1,62K	1	MR25	METAL FILM
R 937	5322 111 44156	510	5	CR16	CARBON
R 939	5322 111 44156	510	5	CR16	CARBON
R 941	4822 111 30327	220	5	CR16	CARBON
R 942	5322 116 54632	14,7K	1	MR25	METAL FILM
R 944	5322 116 50664	2,05K	1	MR25	METAL FILM

ITEM	ORDERING NUMBER	OHM	TOL (%)	TYPE	REMARKS
R 946	5322 116 54608	7,5K	1	MR25	METAL FILM
R 947	5322 116 50508	487	1	MR25	METAL FILM
R 948	5322 116 54617	9,53K	1	MR25	METAL FILM
R 949	5322 116 54576	2,37K	1	MR25	METAL FILM
R 961	5322 116 54408	909K	1	MR30	METAL FILM
R 962	5322 116 54762	365K	1	MR30	METAL FILM
R 963	5322 116 55234	35,2K	0,5	MR25	METAL FILM
R 964	5322 116 55232	17,2K	0,5	MR25	METAL FILM
R 966	5322 116 55235	8,16K	0,5	MR25	METAL FILM
R 967	4822 116 51283	2,71K	0,5	MR25	METAL FILM
R 968	5322 116 55236	898	0,5	MR25	METAL FILM
R 969	5322 116 54722	182K	1	MR25	METAL FILM
R 971	5322 116 55237	89,8K	0,5	MR25	METAL FILM
R 976	5322 116 54549	1K	1	MR25	METAL FILM
R 977	5322 116 50729	4,22K	1	MR25	METAL FILM
R 978	5322 116 50451	21,5K	1	MR25	METAL FILM
R 979	5322 101 14069	22K	20	0.5W	TRIMMING POTM
R 981	5322 116 54005	3,32K	1	MR25	METAL FILM
R 982	5322 116 54549	1K	1	MR25	METAL FILM
R 983	5322 116 50484	4,64K	1	MR25	METAL FILM
R 984	5322 116 50664	2,05K	1	MR25	METAL FILM
R 986	5322 116 50451	21,5K	1	MR25	METAL FILM
R 987	5322 101 14069	22K	20	0.5W	TRIMMING POTM
R 1001	4822 111 30324	100	5	CR16	CARBON
R 1002	5322 111 30396	22	5	CR16	CARBON
R 1003	5322 116 54012	6,81K	1	MR25	METAL FILM
R 1004	4822 111 30263	3,3K	5	CR16	CARBON
R 1006	5322 116 50586	1,54K	1	MR25	METAL FILM
R 1007	5322 116 50895	18,7	1	MR25	METAL FILM
R 1008	5322 116 50895	18,7	1	MR25	METAL FILM
R 1009	5322 111 30396	22	5	CR16	CARBON
R 1011	5322 116 54012	6,81K	1	MR25	METAL FILM
R 1012	5322 116 54525	511	1	MR25	METAL FILM
R 1013	5322 111 30396	22	5	CR16	CARBON
R 1014	5322 116 54592	4,02K	1	MR25	METAL FILM
R 1016	5322 111 30396	22	5	CR16	CARBON
R 1017	5322 116 50415	1,15K	1	MR25	METAL FILM
R 1018	5322 116 50415	1,15K	1	MR25	METAL FILM
R 1019	5322 111 30396	22	5	CR16	CARBON
R 1021	4822 110 63054	10	5	CR25	CARBON
R 1022	5322 116 54683	68,1K	1	MR25	METAL FILM
R 1023	5322 116 50636	2,74K	1	MR25	METAL FILM
R 1024	5322 116 54683	68,1K	1	MR25	METAL FILM
R 1026	5322 116 54552	1,05K	1	MR25	METAL FILM
R 1027	5322 116 50635	1,47K	1	MR25	METAL FILM
R 1028	5322 116 50635	1,47K	1	MR25	METAL FILM
R 1029	5322 116 54552	1,05K	1	MR25	METAL FILM
R 1031	5322 111 30396	22	5	CR16	CARBON
R 1032	5322 111 30396	22	5	CR16	CARBON
R 1033	5322 116 50527	33,2	1	MR25	METAL FILM
R 1034	5322 116 50506	154	1	MR25	METAL FILM
R 1036	5322 116 54508	301	1	MR25	METAL FILM
R 1037	5322 116 54552	1,05K	1	MR25	METAL FILM
R 1038	5322 111 30396	22	5	CR16	CARBON
R 1039	5322 116 54552	1,05K	1	MR25	METAL FILM
R 1040	5322 111 30396	22	5	CR16	CARBON
R 1041	5322 116 54576	2,37K	1	MR25	METAL FILM
R 1042	5322 116 54519	402	1	MR25	METAL FILM
R 1043	4822 110 63054	10	5	CR25	CARBON
R 1044	4822 110 63054	10	5	CR25	CARBON
R 1051	4822 110 63036	2,2	5	CR25	CARBON
R 1052	4822 110 63036	2,2	5	CR25	CARBON
R 1053	4822 110 63063	22	5	CR25	CARBON
R 1054	4822 110 63036	2,2	5	CR25	CARBON
R 1056	5322 116 54576	2,37K	1	MR25	METAL FILM
R 1057	5322 116 54525	511	1	MR25	METAL FILM
R 1058	5322 116 54474	110	1	MR25	METAL FILM
R 1059	5322 111 44153	15	5	CR16	CARBON
R 1061	5322 116 54532	649	1	MR25	METAL FILM
R 1062	5322 116 50729	4,22K	1	MR25	METAL FILM

ITEM	ORDERING NUMBER	OHM	TOL (%)	TYPE	REMARKS
R 1063	5322 116 54011	5,62K	1	MR25	METAL FILM
R 1064	5322 101 14069	22K	20	0.5W	TRIMMING POTM
R 1065	5322 116 50636	2,74K	1	MR25	METAL FILM
R 1066	5322 116 54629	14K	1	MR25	METAL FILM
R 1067	5322 116 54597	5,36K	1	MR25	METAL FILM
R 1068	5322 116 54597	5,36K	1	MR25	METAL FILM
R 1069	5322 116 50415	1,15K	1	MR25	METAL FILM
R 1070	5322 116 54516	365	1	MR25	METAL FILM
R 1071	5322 116 54648	24,9K	1	MR25	METAL FILM
R 1072	5322 116 54519	402	1	MR25	METAL FILM
R 1073	5322 116 54545	909	1	MR25	METAL FILM
R 1075	5322 111 30396	22	5	CR16	CARBON
R 1076	5322 116 54597	5,36K	1	MR25	METAL FILM
R 1077	5322 116 54005	3,32K	1	MR25	METAL FILM
R 1078	5322 116 54603	6,49K	1	MR25	METAL FILM
R 1079	5322 116 50767	2,15K	1	MR25	METAL FILM
R 1081	4822 111 30067	33	5	CR16	CARBON
R 1082	5322 116 54608	7,5K	1	MR25	METAL FILM
R 1083	5322 116 54635	16,9K	1	MR25	METAL FILM
R 1084	4822 111 30067	33	5	CR16	CARBON
R 1086	5322 116 55236	898	0,5	MR25	METAL FILM
R 1087	4822 111 30067	33	5	CR16	CARBON
R 1088	5322 116 50579	3,16K	1	MR25	METAL FILM
R 1089	5322 116 50527	33,2	1	MR25	METAL FILM
R 1091	4822 111 30067	33	5	CR16	CARBON
R 1092	5322 116 54587	3,65K	1	MR25	METAL FILM
R 1093	5322 116 50556	4,42K	1	MR25	METAL FILM
R 1094	5322 116 54595	5,11K	1	MR25	METAL FILM
R 1096	5322 116 50479	15,4K	1	MR25	METAL FILM
R 1097	5322 101 14069	22K	20	0.5W	TRIMMING POTM
R 1098	5322 116 54549	1K	1	MR25	METAL FILM
R 1099	5322 111 30278	27K	5	CR16	CARBON
R 1101	4822 111 30352	82	5	CR16	CARBON
R 1102	4822 111 30245	47	5	CR16	CARBON
R 1103	5322 111 30396	22	5	CR16	CARBON
R 1104	5322 111 30396	22	5	CR16	CARBON
R 1106	5322 111 30279	33K	5	CR16	CARBON
R 1107	5322 116 54565	1,62K	1	MR25	METAL FILM
R 1108	5322 116 54576	2,37K	1	MR25	METAL FILM
R 1109	5322 116 50514	64,9K	1	MR25	METAL FILM
R 1111	5322 116 54595	5,11K	1	MR25	METAL FILM
R 1112	5322 116 50586	1,54K	1	MR25	METAL FILM
R 1113	5322 116 54576	2,37K	1	MR25	METAL FILM
R 1114	5322 116 54557	1,21K	1	MR25	METAL FILM
R 1115	5322 100 10113	10K	20	0,5W	TRIMMING POTM
R 1116	5322 116 54469	100	1	MR25	METAL FILM
R 1117	5322 116 54561	1,33K	1	MR25	METAL FILM
R 1118	5322 116 54576	2,37K	1	MR25	METAL FILM
R 1119	5322 116 54617	9,53K	1	MR25	METAL FILM
R 1121	5322 116 54561	1,33K	1	MR25	METAL FILM
R 1122	5322 116 50524	3,01K	1	MR25	METAL FILM
R 1123	5322 116 54561	1,33K	1	MR25	METAL FILM
R 1124	4822 111 30067	33	5	CR16	CARBON
R 1126	4822 111 30067	33	5	CR16	CARBON
R 1127	5322 116 54617	9,53K	1	MR25	METAL FILM
R 1128	5322 116 50583	5,9K	1	MR25	METAL FILM
R 1129	5322 116 54592	4,02K	1	MR25	METAL FILM
R 1163	5322 116 55234	35,2K	0,5	MR25	METAL FILM
R 1164	5322 116 55232	17,2K	0,5	MR25	METAL FILM
R 1166	5322 116 55235	8,16K	0,5	MR25	METAL FILM
R 1167	4822 116 51283	2,71K	0,5	MR25	METAL FILM
R 1168	5322 116 55236	898	0,5	MR25	METAL FILM
R 1169	5322 116 54722	182K	1	MR25	METAL FILM
R 1171	5322 116 55237	89,8K	0,5	MR25	METAL FILM
R 1201	5322 116 54558	8,25K	1	MR25	METAL FILM
R 1202	5322 116 50479	15,4K	1	MR25	METAL FILM
R 1203	5322 116 50484	4,64K	1	MR25	METAL FILM
R 1204	4822 111 30067	33	5	CR16	CARBON
R 1206	5322 116 54619	10K	1	MR25	METAL FILM
R 1207	5322 116 50579	3,16K	1	MR25	METAL FILM

ITEM	ORDERING NUMBER	OHM	TOL (%)	TYPE	REMARKS
R 1208	5322 116 54619	10K	1	MR25	METAL FILM
R 1209	5322 101 14008	2,2K	20	0.5W	TRIMMING POTM
R 1211	5322 116 50621	536	1	MR25	METAL FILM
R 1212	5322 116 54524	499	1	MR25	METAL FILM
R 1213	5322 116 50621	536	1	MR25	METAL FILM
R 1214	5322 116 50511	48,7	1	MR25	METAL FILM
R 1216	5322 116 50457	215	1	MR25	METAL FILM
R 1217	4822 111 30333	1M	10	CR16	CARBON
R 1218	4822 111 30333	1M	10	CR16	CARBON
R 1219	5322 116 54619	10K	1	MR25	METAL FILM
R 1221	5322 116 50511	48,7	1	MR25	METAL FILM
R 1222	5322 116 50579	3,16K	1	MR25	METAL FILM
R 1223	5322 100 10113	10K	20	0,5W	TRIMMING POTM
R 1224	5322 116 50579	3,16K	1	MR25	METAL FILM
R 1225	5322 116 50728	1,87K	1	MR25	METAL FILM
R 1226	5322 116 55277	9,09K	1	MR25	METAL FILM
R 1227	5322 116 54545	909	1	MR25	METAL FILM
R 1228	5322 116 54545	909	1	MR25	METAL FILM
R 1229	4822 111 30067	33	5	CR16	CARBON
R 1231	5322 116 50583	5,9K	1	MR25	METAL FILM
R 1232	5322 116 54012	6,81K	1	MR25	METAL FILM
R 1233	5322 116 50555	1,27K	1	MR25	METAL FILM
R 1234	5322 116 54716	162K	1	MR25	METAL FILM
R 1235	5322 116 50673	147K	1	MR30	METAL FILM
R 1236	4822 111 30067	33	5	CR16	CARBON
R 1237	5322 116 54661	34,8K	1	MR25	METAL FILM
R 1238	4822 111 30067	33	5	CR16	CARBON
R 1239	5322 116 54549	1K	1	MR25	METAL FILM
R 1241	5322 116 54337	332K	1	MR30	METAL FILM
R 1242	5322 116 54661	34,8K	1	MR25	METAL FILM
R 1243	4822 111 30067	33	5	CR16	CARBON
R 1244	5322 116 55277	9,09K	1	MR25	METAL FILM
R 1246	5322 116 54592	4,02K	1	MR25	METAL FILM
R 1247	5322 116 54587	3,65K	1	MR25	METAL FILM
R 1248	4822 111 30067	33	5	CR16	CARBON
R 1249	5322 116 54661	34,8K	1	MR25	METAL FILM
R 1251	5322 116 54661	34,8K	1	MR25	METAL FILM
R 1252	5322 116 54549	1K	1	MR25	METAL FILM
R 1253	5322 116 54188	1M	1	MR30	METAL FILM
R 1254	4822 111 30067	33	5	CR16	CARBON
R 1256	5322 116 54716	162K	1	MR25	METAL FILM
R 1257	4822 111 30067	33	5	CR16	CARBON
R 1258	5322 116 50555	1,27K	1	MR25	METAL FILM
R 1301	5322 116 54534	681	1	MR25	METAL FILM
R 1302	5322 116 50586	1,54K	1	MR25	METAL FILM
R 1303	5322 116 54532	649	1	MR25	METAL FILM
R 1304	5322 116 50492	46,4	1	MR25	METAL FILM
R 1306	5322 116 54571	1,96K	1	MR25	METAL FILM
R 1307	5322 116 50572	12,1K	1	MR25	METAL FILM
R 1308	5322 116 50767	2,15K	1	MR25	METAL FILM
R 1309	5322 116 54549	1K	1	MR25	METAL FILM
R 1311	5322 116 50635	1,47K	1	MR25	METAL FILM
R 1312	5322 116 50492	46,4	1	MR25	METAL FILM
R 1313	5322 116 50492	46,4	1	MR25	METAL FILM
R 1314	5322 116 54592	4,02K	1	MR25	METAL FILM
R 1316	5322 116 54469	100	1	MR25	METAL FILM
R 1317	5322 116 54619	10K	1	MR25	METAL FILM
R 1318	5322 116 50492	46,4	1	MR25	METAL FILM
R 1319	5322 116 50524	3,01K	1	MR25	METAL FILM
R 1321	5322 116 50452	10	1	MR25	METAL FILM
R 1322	5322 116 54694	90,9K	1	MR25	METAL FILM
R 1323	5322 116 54624	11,5K	1	MR25	METAL FILM
R 1324	5322 116 50581	2,49K	1	MR25	METAL FILM
R 1325	5322 116 55276	13,3K	1	MR25	METAL FILM
R 1326	5322 116 50524	3,01K	1	MR25	METAL FILM
R 1327	5322 100 10113	10K	20	0,5W	TRIMMING POTM
R 1328	5322 116 50536	464	1	MR25	METAL FILM
R 1329	5322 116 54619	10K	1	MR25	METAL FILM
R 1330	5322 116 50568	4,99	1	MR25	METAL FILM
R 1331	5322 116 50442	48,7K	1	MR25	METAL FILM

ITEM	ORDERING NUMBER	OHM	TOL (%)	TYPE	REMARKS
R 1332	5322 116 50442	48,7K	1	MR25	METAL FILM
R 1333	4822 110 63187	1M	5	CR25	CARBON
R 1334	4822 110 63187	1M	5	CR25	CARBON
R 1336	5322 116 54525	511	1	MR25	METAL FILM
R 1337	4822 110 63161	100K	5	CR25	CARBON
R 1338	4822 110 42189	1,2M	5	VR37	CARBON
R 1339	4822 110 42196	2,2M	5	VR37	CARBON
R 1340	5322 116 54071	10,5	1	MR25	METAL FILM
R 1341	4822 110 42207	5,6M	5	VR37	CARBON
R 1342	5322 116 54689	82,5K	1	MR25	METAL FILM
R 1343	5322 116 54721	178K	1	MR25	METAL FILM
R 1344	5322 101 14071	100K	20	0.5W	TRIMMING POTM
R 1346	5322 101 14094	1M	20	0,5W	TRIMMING POTM
R 1347	5322 116 54704	121K	1	MR25	METAL FILM
R 1348	5322 116 54743	301K	1	MR25	METAL FILM
R 1349	5322 116 54696	100K	1	MR25	METAL FILM
R 1350	5322 116 54696	100K	1	MR25	METAL FILM
R 1351	5322 116 54619	10K	1	MR25	METAL FILM
R 1352	5322 116 54502	261	1	MR25	METAL FILM
R 1353	5322 116 54502	261	1	MR25	METAL FILM
R 1354	5322 116 54516	365	1	MR25	METAL FILM
R 1356	5322 116 50583	5,9K	1	MR25	METAL FILM
R 1357	5322 116 54549	1K	1	MR25	METAL FILM
R 1361	5322 116 54469	100	1	MR25	METAL FILM
R 1362	5322 100 10114	4,7K	20	0.5W	TRIMMING POTM
R 1363	5322 116 50635	1,47K	1	MR25	METAL FILM
R 1364	5322 116 50608	6,19K	1	MR25	METAL FILM
R 1366	5322 116 54536	750	1	MR25	METAL FILM
R 1367	5322 116 55008	499	0,1	MR24E	METAL FILM
R 1368	5322 116 54639	19,1K	1	MR25	METAL FILM
R 1369	5322 116 54502	261	1	MR25	METAL FILM
R 1371	5322 116 50608	6,19K	1	MR25	METAL FILM
R 1372	5322 116 54469	100	1	MR25	METAL FILM
R 1401	5322 116 54665	40,2K	1	MR25	METAL FILM
R 1402	5322 116 50442	48,7K	1	MR25	METAL FILM
R 1403	5322 116 54683	68,1K	1	MR25	METAL FILM
R 1404	5322 116 50474	42,2K	1	MR25	METAL FILM
R 1406	5322 116 54549	1K	1	MR25	METAL FILM
R 1407	5322 116 54696	100K	1	MR25	METAL FILM
R 1408	5322 116 54632	14,7K	1	MR25	METAL FILM
R 1409	5322 116 50672	51,1K	1	MR25	METAL FILM
R 1416	5322 111 50345	8,2M	5	1W	CARBON
R 1800	4822 110 63041	3,3	5	CR25	CARBON
R 1801	5322 113 60064	2,7	10	2W	WIRE-WOUND
R 1802	5322 116 54643	20,5K	1	MR25	METAL FILM
R 1803	5322 116 54696	100K	1	MR25	METAL FILM
R 1804	5322 116 54696	100K	1	MR25	METAL FILM
R 1805	5322 116 54469	100	1	MR25	METAL FILM
R 1806	4822 110 63198	2,7M	10	CR25	CARBON
R 1807	5322 116 50442	48,7K	1	MR25	METAL FILM
R 1808	5322 116 54696	100K	1	MR25	METAL FILM
R 1811	4822 110 63041	3,3	5	CR25	CARBON
R 1814	5322 116 50766	147	1	MR25	METAL FILM
R 1815	5322 116 50557	46,4K	1	MR25	METAL FILM
R 1816	5322 116 54005	3,32K	1	MR25	METAL FILM
R 1818	5322 116 50417	162	1	MR25	METAL FILM
R 1819	5322 110 50035	2	5	CR37	CARBON
R 1820	5322 116 34028	150K	5	0.5W	NTC
R 1821	5322 116 55149	24,9K	1	MR30	METAL FILM
R 1822	5322 116 54549	1K	1	MR25	METAL FILM
R 1823	5322 116 50452	10	1	MR25	METAL FILM
R 1824	5322 116 50731	10,5K	1	MR25	METAL FILM
R 1826	5322 116 54549	1K	1	MR25	METAL FILM
R 1827	5322 116 54564	1,5K	1	MR25	METAL FILM
R 1828	5322 116 50636	2,74K	1	MR25	METAL FILM
R 1829	5322 116 50767	2,15K	1	MR25	METAL FILM
R 1830	5322 116 54619	10K	1	MR25	METAL FILM
R 1831	5322 116 54549	1K	1	MR25	METAL FILM
R 1832	5322 116 54558	8,25K	1	MR25	METAL FILM
R 1833	5322 116 50515	1,78K	1	MR25	METAL FILM
R 1834	5322 100 10112	1K	20	0,5W	TRIMMING POTM

ITEM	ORDERING NUMBER	OHM	TOL (%)	TYPE	REMARKS
R 1835	5322 116 54192	5,11	1	MR25	METAL FILM
R 1836	5322 116 54558	8,25K	1	MR25	METAL FILM
R 1837	4822 110 63178	470K	5	CR25	CARBON
R 1838	5322 116 54629	14K	1	MR25	METAL FILM
R 1839	5322 116 54592	4,02K	1	MR25	METAL FILM
R 1840	4822 110 23156	68K	5	CR68	CARBON
R 1841	5322 101 14144	470K	20	0.5W	TRIMMING POTM
R 1842	5322 116 54655	30,1K	1	MR25	METAL FILM
R 1843	5322 116 54643	20,5K	1	MR25	METAL FILM
R 1844	5322 116 54643	20,5K	1	MR25	METAL FILM
R 1845	5322 116 54525	511	1	MR25	METAL FILM
R 1846	5322 116 54696	100K	1	MR25	METAL FILM
R 1847	5322 116 54469	100	1	MR25	METAL FILM
R 1848	5322 116 54469	100	1	MR25	METAL FILM
R 1849	5322 116 54619	10K	1	MR25	METAL FILM
R 1851	5322 116 54648	24,9K	1	MR25	METAL FILM
R 2376	5322 116 54012	6,81K	1	MR25	METAL FILM
R 2377	5322 116 54595	5,11K	1	MR25	METAL FILM
R 2378	5322 116 50558	18,7K	1	MR25	METAL FILM
R 2379	5322 101 14048	47K	20	0,5W	TRIMMING POTM
R 2381	5322 116 50527	33,2	1	MR25	METAL FILM
R 2382	4822 111 30067	33	5	CR16	CARBON
R 2383	5322 116 54557	1,21K	1	MR25	METAL FILM
R 2387	5322 116 50452	10	1	MR25	METAL FILM
R 2388	5322 116 54519	402	1	MR25	METAL FILM
R 2389	5322 116 54469	100	1	MR25	METAL FILM
R 2390	5322 116 54541	825	1	MR25	METAL FILM
R 2391	5322 116 50568	4,99	1	MR25	METAL FILM
R 2392	5322 116 50527	33,2	1	MR25	METAL FILM
R 2393	4822 111 30324	100	5	CR16	CARBON
R 2394	5322 116 54439	35,7	1	MR25	METAL FILM
R 2396	5322 116 54548	976	1	MR25	METAL FILM
R 2397	5322 116 54439	35,7	1	MR25	METAL FILM
R 2398	4822 111 30324	100	5	CR16	CARBON
R 2401	5322 116 50524	3,01K	1	MR25	METAL FILM
R 2402	5322 116 54508	30.	1	MR25	METAL FILM
R 2403	4822 111 30067	33	5	CR16	CARBON
R 2404	5322 116 50524	3,01K	1	MR25	METAL FILM
R 2405	5322 116 54464	86,6	1	MR25	METAL FILM
R 2406	4822 111 30347	10	5	CR16	CARBON
R 2407	5322 116 50492	46,4	1	MR25	METAL FILM
R 2408	5322 116 50568	4,99	1	MR25	METAL FILM
R 2409	5322 116 50492	46,4	1	MR25	METAL FILM
R 2410	5322 116 34036	47	5	0.5W	NTC
R 2411	4822 111 30347	10	5	CR16	CARBON
R 2412	4822 111 30067	33	5	CR16	CARBON
R 2413	5322 116 50515	1,78K	1	MR25	METAL FILM
R 2414	5322 116 54005	3,32K	1	MR25	METAL FILM
R 2416	5322 116 50452	10	1	MR25	METAL FILM
R 2417	5322 116 50571	715	1	MR25	METAL FILM
R 2418	4822 111 30245	47	5	CR16	CARBON
R 2419	4822 111 30347	10	5	CR16	CARBON
R 2420	5322 116 54464	86,6	1	MR25	METAL FILM
R 2421	4822 111 30067	33	5	CR16	CARBON
R 2422	5322 116 54492	178	1	MR25	METAL FILM
R 2423	4822 111 30067	33	5	CR16	CARBON
R 2424	5322 116 54576	2,37K	1	MR25	METAL FILM
R 2426	5322 116 54587	3,65K	1	MR25	METAL FILM
R 2427	5322 116 50527	33,2	1	MR25	METAL FILM
R 2428	4822 111 30067	33	5	CR16	CARBON
R 2429	5322 116 54492	178	1	MR25	METAL FILM
R 2431	4822 111 30347	10	5	CR16	CARBON
R 2432	5322 116 50571	715	1	MR25	METAL FILM
R 2433	4822 111 30245	47	5	CR16	CARBON
R 2434	5322 116 50452	10	1	MR25	METAL FILM
R 2436	4822 111 30067	33	5	CR16	CARBON
R 2437	5322 116 54613	8,66K	1	MR25	METAL FILM
R 2438	5322 116 54005	3,32K	1	MR25	METAL FILM
R 2439	4822 111 30067	33	5	CR16	CARBON
R 2440	5322 116 54581	2,94K	1	MR25	METAL FILM

ITEM	ORDERING NUMBER	OHM	TOL (%)	TYPE	REMARKS
R 2441	5322 116 50926	40,2	1	MR25	METAL FILM
R 2442	5322 100 10112	1K	20	0,5W	TRIMMING POTM
R 2443	5322 116 54515	348	1	MR25	METAL FILM
R 2444	5322 116 50926	40,2	1	MR25	METAL FILM
R 2445	5322 116 54595	5,11K	1	MR25	METAL FILM
R 2446	4822 111 30067	33	5	CR16	CARBON
R 2447	5322 116 50442	48,7K	1	MR25	METAL FILM
R 2448	5322 100 10113	10K	20	0,5W	TRIMMING POTM
R 2461	5322 116 54005	3,32K	1	MR25	METAL FILM
R 2463	5322 116 54576	2,37K	1	MR25	METAL FILM
R 2464	5322 116 54005	3,32K	1	MR25	METAL FILM
R 2465	5322 116 54012	6,81K	1	MR25	METAL FILM
R 2466	5322 116 54585	3,48K	1	MR25	METAL FILM
R 2467	4822 111 30067	33	5	CR16	CARBON
R 2468	4822 111 30067	33	5	CR16	CARBON
R 2469	4822 111 30067	33	5	CR16	CARBON
R 2471	4822 111 30067	33	5	CR16	CARBON
R 2472	4822 111 30067	33	5	CR16	CARBON
R 2473	4822 111 30067	33	5	CR16	CARBON
R 2474	4822 111 30067	33	5	CR16	CARBON
R 2476	4822 111 30067	33	5	CR16	CARBON
R 2477	4822 111 30067	33	5	CR16	CARBON
R 2478	5322 116 54469	100	1	MR25	METAL FILM
R 2479	5322 116 50621	536	1	MR25	METAL FILM
R 2481	4822 111 30067	33	5	CR16	CARBON
R 2482	5322 116 54469	100	1	MR25	METAL FILM
R 2483	4822 111 30067	33	5	CR16	CARBON
R 2484	5322 116 54613	8,66K	1	MR25	METAL FILM
R 2486	5322 116 50524	3,01K	1	MR25	METAL FILM
R 2487	5322 116 50527	33,2	1	MR25	METAL FILM
R 2488	5322 116 54469	100	1	MR25	METAL FILM
R 2576	5322 116 54012	6,81K	1	MR25	METAL FILM
R 2577	5322 116 54595	5,11K	1	MR25	METAL FILM
R 2578	5322 116 50558	18,7K	1	MR25	METAL FILM
R 2579	5322 101 14048	47K	20	0,5W	TRIMMING POTM
R 2581	5322 116 50527	33,2	1	MR25	METAL FILM
R 2582	4822 111 30067	33	5	CR16	CARBON
R 2583	5322 116 54557	1,21K	1	MR25	METAL FILM
R 2587	5322 116 50452	10	1	MR25	METAL FILM
R 2588	5322 116 54519	402	1	MR25	METAL FILM
R 2589	5322 116 54469	100	1	MR25	METAL FILM
R 2590	5322 116 54541	825	1	MR25	METAL FILM
R 2591	5322 116 50568	4,99	1	MR25	METAL FILM
R 2592	5322 116 50527	33,2	1	MR25	METAL FILM
R 2593	4822 111 30324	100	5	CR16	CARBON
R 2594	5322 116 54439	35,7	1	MR25	METAL FILM
R 2596	5322 116 54548	976	1	MR25	METAL FILM
R 2597	5322 116 54439	35,7	1	MR25	METAL FILM
R 2598	4822 111 30324	100	5	CR16	CARBON
R 2601	5322 116 50524	3,01K	1	MR25	METAL FILM
R 2602	5322 116 54508	301	1	MR25	METAL FILM
R 2603	4822 111 30067	33	5	CR16	CARBON
R 2604	5322 116 50524	3,01K	1	MR25	METAL FILM
R 2605	5322 116 54464	86,6	1	MR25	METAL FILM
R 2606	4822 111 30347	10	5	CR16	CARBON
R 2607	5322 116 50492	46,4	1	MR25	METAL FILM
R 2608	5322 116 50568	4,99	1	MR25	METAL FILM
R 2609	5322 116 50492	46,4	1	MR25	METAL FILM
R 2610	5322 116 34036	47	5	0.5W	NTC
R 2611	4822 111 30347	10	5	CR16	CARBON
R 2612	4822 111 30067	33	5	CR16	CARBON
R 2613	5322 116 50515	1,78K	1	MR25	METAL FILM
R 2614	5322 116 54005	3,32K	1	MR25	METAL FILM
R 2616	5322 116 50452	10	1	MR25	METAL FILM
R 2617	5322 116 50571	715	1	MR25	METAL FILM
R 2618	4822 111 30245	47	5	CR16	CARBON
R 2619	4822 111 30347	10	5	CR16	CARBON
R 2620	5322 116 54464	86,6	1	MR25	METAL FILM
R 2621	4822 111 30067	33	5	CR16	CARBON
R 2622	5322 116 54492	178	1	MR25	METAL FILM

ITEM	ORDERING NUMBER	OHM	TOL (%)	TYPE	REMARKS
R 2623	4822 111 30067	33	5	CR16	CARBON
R 2624	5322 116 54576	2,37K	1	MR25	METAL FILM
R 2626	5322 116 54587	3,65K	1	MR25	METAL FILM
R 2627	5322 116 50527	33,2	1	MR25	METAL FILM
R 2628	4822 111 30067	33	5	CR16	CARBON
R 2629	5322 116 54492	178	1	MR25	METAL FILM
R 2631	4822 111 30347	10	5	CR16	CARBON
R 2632	5322 116 50571	715	1	MR25	METAL FILM
R 2633	4822 111 30245	47	5	CR16	CARBON
R 2634	5322 116 50452	10	1	MR25	METAL FILM
R 2636	4822 111 30067	33	5	CR16	CARBON
R 2637	5322 116 54613	8,66K	1	MR25	METAL FILM
R 2638	5322 116 54005	3,32K	1	MR25	METAL FILM
R 2639	4822 111 30067	33	5	CR16	CARBON
R 2640	5322 116 54581	2,94K	1	MR25	METAL FILM
R 2641	5322 116 50926	40,2	1	MR25	METAL FILM
R 2642	5322 100 10112	1K	20	0,5W	TRIMMING POTM
R 2643	5322 116 54515	348	1	MR25	METAL FILM
R 2644	5322 116 50926	40,2	1	MR25	METAL FILM
R 2645	5322 116 54595	5,11K	1	MR25	METAL FILM
R 2646	4822 111 30067	33	5	CR16	CARBON
R 2647	5322 116 50442	48,7K	1	MR25	METAL FILM
R 2648	5322 100 10113	10K	20	0,5W	TRIMMING POTM
R 2661	5322 116 54005	3,32K	1	MR25	METAL FILM
R 2663	5322 116 54576	2,37K	1	MR25	METAL FILM
R 2664	5322 116 54005	3,32K	1	MR25	METAL FILM
R 2665	5322 116 54012	6,81K	1	MR25	METAL FILM
R 2666	5322 116 54585	3,48K	1	MR25	METAL FILM
R 2667	4822 111 30067	33	5	CR16	CARBON
R 2668	4822 111 30067	33	5	CR16	CARBON
R 2669	4822 111 30067	33	5	CR16	CARBON
R 2671	4822 111 30067	33	5	CR16	CARBON
R 2672	4822 111 30067	33	5	CR16	CARBON
R 2673	4822 111 30067	33	5	CR16	CARBON
R 2674	4822 111 30067	33	5	CR16	CARBON
R 2676	4822 111 30067	33	5	CR16	CARBON
R 2677	4822 111 30067	33	5	CR16	CARBON
R 2678	5322 116 54469	100	1	MR25	METAL FILM
R 2679	5322 116 50621	536	1	MR25	METAL FILM
R 2681	4822 111 30067	33	5	CR16	CARBON
R 2682	5322 116 54469	100	1	MR25	METAL FILM
R 2683	4822 111 30067	33	5	CR16	CARBON
R 2684	5322 116 54613	8,66K	1	MR25	METAL FILM
R 2686	5322 116 50524	3,01K	1	MR25	METAL FILM
R 2687	5322 116 50527	33,2	1	MR25	METAL FILM
R 2688	5322 116 54469	100	1	MR25	METAL FILM
R 2776	5322 116 54012	6,81K	1	MR25	METAL FILM
R 2777	5322 116 54595	5,11K	1	MR25	METAL FILM
R 2778	5322 116 50558	18,7K	1	MR25	METAL FILM
R 2779	5322 101 14048	47K	20	0,5W	TRIMMING POTM
R 2781	5322 116 50527	33,2	1	MR25	METAL FILM
R 2782	4822 111 30067	33	5	CR16	CARBON
R 2783	5322 116 54557	1,21K	1	MR25	METAL FILM
R 2787	5322 116 50452	10	1	MR25	METAL FILM
R 2788	5322 116 54519	402	1	MR25	METAL FILM
R 2789	5322 116 54469	100	1	MR25	METAL FILM
R 2790	5322 116 54541	825	1	MR25	METAL FILM
R 2791	5322 116 50568	4,99	1	MR25	METAL FILM
R 2792	5322 116 50527	33,2	1	MR25	METAL FILM
R 2793	4822 111 30324	100	5	CR16	CARBON
R 2794	5322 116 54439	35,7	1	MR25	METAL FILM
R 2796	5322 116 54548	976	1	MR25	METAL FILM
R 2797	5322 116 54439	35,7	1	MR25	METAL FILM
R 2798	4822 111 30324	100	5	CR16	CARBON
R 2801	5322 116 50524	3,01K	1	MR25	METAL FILM
R 2802	5322 116 54508	301	1	MR25	METAL FILM
R 2803	4822 111 30067	33	5	CR16	CARBON
R 2804	5322 116 50524	3,01K	1	MR25	METAL FILM
R 2805	5322 116 54464	86,6	1	MR25	METAL FILM
R 2806	4822 111 30347	10	5	CR16	CARBON

ITEM	ORDERING NUMBER	OHM	TOL (%)	TYPE	REMARKS
R 2807	5322 116 50492	46,4	1	MR25	METAL FILM
R 2808	5322 116 50568	4,99	1	MR25	METAL FILM
R 2809	5322 116 50492	46,4	1	MR25	METAL FILM
R 2810	5322 116 34036	47	5	0.5W	NTC
R 2811	4822 111 30347	10	5	CR16	CARBON
R 2812	4822 111 30067	33	5	CR16	CARBON
R 2813	5322 116 50515	1,78K	1	MR25	METAL FILM
R 2814	5322 116 54005	3,32K	1	MR25	METAL FILM
R 2816	5322 116 50452	10	1	MR25	METAL FILM
R 2817	5322 116 50571	715	1	MR25	METAL FILM
R 2818	4822 111 30245	47	5	CR16	CARBON
R 2819	4822 111 30347	10	5	CR16	CARBON
R 2820	5322 116 54464	86,6	1	MR25	METAL FILM
R 2821	4822 111 30067	33	5	CR16	CARBON
R 2822	5322 116 54492	178	1	MR25	METAL FILM
R 2823	4822 111 30067	33	5	CR16	CARBON
R 2824	5322 116 54576	2,37K	1	MR25	METAL FILM
R 2826	5322 116 54587	3,65K	1	MR25	METAL FILM
R 2827	5322 116 50527	33,2	1	MR25	METAL FILM
R 2828	4822 111 30067	33	5	CR16	CARBON
R 2829	5322 116 54492	178	1	MR25	METAL FILM
R 2831	4822 111 30347	10	5	CR16	CARBON
R 2832	5322 116 50571	715	1	MR25	METAL FILM
R 2833	4822 111 30245	47	5	CR16	CARBON
R 2834	5322 116 50452	10	1	MR25	METAL FILM
R 2836	4822 111 30067	33	5	CR16	CARBON
R 2837	5322 116 54613	8,66K	1	MR25	METAL FILM
R 2838	5322 116 54005	3,32K	1	MR25	METAL FILM
R 2839	4822 111 30067	33	5	CR16	CARBON
R 2840	5322 116 54581	2,94K	1	MR25	METAL FILM
R 2841	5322 116 50926	40,2	1	MR25	METAL FILM
R 2842	5322 100 10112	1K	20	0,5W	TRIMMING POTM
R 2843	5322 116 54515	348	1	MR25	METAL FILM
R 2844	5322 116 50926	40,2	1	MR25	METAL FILM
R 2845	5322 116 54595	5,11K	1	MR25	METAL FILM
R 2846	4822 111 30067	33	5	CR16	CARBON
R 2847	5322 116 50442	48,7K	1	MR25	METAL FILM
R 2848	5322 100 10113	10K	20	0,5W	TRIMMING POTM
R 2861	5322 116 54005	3,32K	1	MR25	METAL FILM
R 2863	5322 116 54576	2,37K	1	MR25	METAL FILM
R 2864	5322 116 54005	3,32K	1	MR25	METAL FILM
R 2865	5322 116 54012	6,81K	1	MR25	METAL FILM
R 2866	5322 116 54585	3,48K	1	MR25	METAL FILM
R 2867	4822 111 30067	33	5	CR16	CARBON
R 2868	4822 111 30067	33	5	CR16	CARBON
R 2869	4822 111 30067	33	5	CR16	CARBON
R 2871	4822 111 30067	33	5	CR16	CARBON
R 2872	4822 111 30067	33	5	CR16	CARBON
R 2873	4822 111 30067	33	5	CR16	CARBON
R 2874	4822 111 30067	33	5	CR16	CARBON
R 2876	4822 111 30067	33	5	CR16	CARBON
R 2877	4822 111 30067	33	5	CR16	CARBON
R 2878	5322 116 54469	100	1	MR25	METAL FILM
R 2879	5322 116 50621	536	1	MR25	METAL FILM
R 2881	4822 111 30067	33	5	CR16	CARBON
R 2882	5322 116 54469	100	1	MR25	METAL FILM
R 2883	4822 111 30067	33	5	CR16	CARBON
R 2884	5322 116 54613	8,66K	1	MR25	METAL FILM
R 2886	5322 116 50524	3,01K	1	MR25	METAL FILM
R 2887	5322 116 50527	33,2	1	MR25	METAL FILM
R 2888	5322 116 54469	100	1	MR25	METAL FILM

Diodes

ITEM	ORDERING NUMBER	TYPE/DESCRIPTION
GR1	4822 130 31144	CQY24B-III PH
GR2	5322 130 34595	CQY24A-I PH
GR101	5322 130 34037	BAV45
GR102	5322 130 30283	AAZ17
GR401	4822 130 30613	BAW62
GR501	4822 130 30613	BAW62
GR502	4822 130 34278	BZX79-C6V8
GR601	5322 130 30644	BA182
GR602	5322 130 30644	BA182
GR603	4822 130 30862	BZX79-C9V1
GR604	4822 130 30861	BZX79-B7V5 PH
GR606	4822 130 34382	BZX79-B8V2
GR607	4822 130 34382	BZX79-B8V2
GR608	4822 130 30861	BZX79-B7V5 PH
GR609	4822 130 30862	BZX79-C9V1
GR701	4822 130 30613	BAW62
GR702	4822 130 30613	BAW62
GR703	4822 130 30613	BAW62
GR704	4822 130 30613	BAW62
GR706	4822 130 30613	BAW62
GR707	4822 130 30613	BAW62
GR708	4822 130 30613	BAW62
GR709	4822 130 30613	BAW62
GR710	4822 130 30613	BAW62
GR711	4822 130 30613	BAW62
GR712	4822 130 30613	BAW62
GR713	4822 130 34173	BZX79-B5V6
GR751	4822 130 30613	BAW62
GR752	4822 130 30613	BAW62
GR753	4822 130 30613	BAW62
GR754	4822 130 30613	BAW62
GR756	4822 130 30613	BAW62
GR757	4822 130 30613	BAW62
GR761	4822 130 30613	BAW62
GR762	4822 130 30613	BAW62
GR763	4822 130 30613	BAW62
GR764	4822 130 30613	BAW62
GR766	4822 130 30613	BAW62
GR767	4822 130 30613	BAW62
GR771	4822 130 30613	BAW62
GR772	4822 130 30613	BAW62
GR773	4822 130 30613	BAW62
GR774	4822 130 30613	BAW62
GR776	4822 130 30613	BAW62
GR777	4822 130 30613	BAW62
GR781	4822 130 30613	BAW62
GR782	4822 130 30613	BAW62
GR783	4822 130 30613	BAW62
GR784	4822 130 30613	BAW62
GR786	4822 130 30613	BAW62
GR787	4822 130 30613	BAW62
GR791	4822 130 30613	BAW62
GR792	4822 130 30613	BAW62
GR793	4822 130 30613	BAW62
GR794	4822 130 30613	BAW62
GR796	4822 130 30613	BAW62
GR797	4822 130 30613	BAW62
GR801	4822 130 34048	BZX75-C2V8
GR802	4822 130 30613	BAW62
GR803	4822 130 30613	BAW62
GR804	4822 130 30613	BAW62
GR806	4822 130 30613	BAW62
GR807	4822 130 30229	AAZ15
GR851	4822 130 30613	BAW62
GR853	4822 130 30613	BAW62
GR854	4822 130 30613	BAW62
GR855	4822 130 30229	AAZ15
GR856	4822 130 30613	BAW62

ITEM	ORDERING NUMBER	TYPE/DESCRIPTION	
GR857	4822 130 30613	BAW62	
GR858	4822 130 34174	BZX79-C4V7	
GR861	4822 130 30613	BAW62	
GR862	4822 130 30613	BAW62	
GR863	4822 130 30613	BAW62	
GR1001	4822 130 34048	BZX75-C2V8	
GR1002	4822 130 30613	BAW62	
GR1003	4822 130 30613	BAW62	
GR1004	4822 130 30613	BAW62	
GR1006	4822 130 30613	BAW62	
GR1051	4822 130 30613	BAW62	
GR1052	4822 130 30613	BAW62	
GR1053	4822 130 30613	BAW62	
GR1054	4822 130 30613	BAW62	
GR1056	4822 130 30613	BAW62	
GR1057	4822 130 30613	BAW62	
GR1058	4822 130 30613	BAW62	
GR1059	4822 130 30613	BAW62	
GR1061	4822 130 30613	BAW62	
GR1062	4822 130 30613	BAW62	
GR1063	4822 130 30613	BAW62	
GR1064	4822 130 30613	BAW62	
GR1065	4822 130 30613	BAW62	
GR1066	4822 130 30613	BAW62	
GR1067	4822 130 30613	BAW62	
GR1201	4822 130 30613	BAW62	
GR1202	4822 130 30613	BAW62	
GR1203	4822 130 30613	BAW62	
GR1204	4822 130 30613	BAW62	
GR1207	4822 130 34173	BZX79-C5V6	
GR1208	4822 130 34384	BZX79-B62	
GR1209	4822 130 34383	BZX79-B47	
GR1211	4822 130 34384	BZX79-B62	
GR1212	4822 130 34173	BZX79-C5V6	
GR1301	4822 130 30613	BAW62	
GR1302	4822 130 30613	BAW62	
GR1303	5322 130 30392	BZY88-C3V3	
GR1304	4822 130 30613	BAW62	
GR1306	4822 130 30842	BAV21	
GR1307	4822 130 30842	BAV21	
GR1308	4822 130 30842	BAV21	
GR1309	4822 130 30842	BAV21	
GR1311	4822 130 30613	BAW62	
GR1312	4822 130 30613	BAW62	
GR1316	4822 130 34173	BZX79-C5V6	
GR1317	4822 130 34173	BZX79-C5V6	
GR1401	4822 130 30842	BAV21	
GR1402	4822 130 30842	BAV21	
GR1403	5322 130 34594	BY409-A	
GR1416	5322 130 34594	BY409-A	
GR1417	5322 130 34594	BY409-A	
GR1418	5322 130 34594	BY409-A	
GR1419	5322 130 34594	BY409-A	
GR1421	5322 130 34594	BY409-A	
GR1801	4822 130 30521	BY179	PH
GR1802	5322 130 34107	BZX61-C13	
GR1803	5322 130 34297	BZX79-C10	
GR1804	4822 130 30817	BYX55-600	
GR1805	5322 130 34605	BAX12	
GR1806	5322 130 34034	BZX61-C75	
GR1807	5322 130 30565	BZX61-C47	
GR1808	4822 130 30613	BAW62	
GR1809	4822 130 30839	BY206	PH
GR1811	4822 130 30839	BY206	PH
GR1812	4822 130 30839	BY206	PH
GR1813	4822 130 30613	BAW62	
GR1815	4822 130 30613	BAW62	
GR1816	4822 130 34047	BZX75-C1V4	
GR1817	4822 130 30613	BAW62	
GR1818	4822 130 30613	BAW62	
GR1819	4822 130 30195	BYX10	PH
GR1820	4822 130 30613	BAW62	
GR1821	5322 130 34297	BZX79-C10	
GR1822	5322 130 34605	BAX12	
GR1823	4822 130 30839	BY206	PH

ITEM	ORDERING NUMBER	TYPE/DESCRIPTION
GR1824	4822 130 30839	BY206 PH
GR1825	4822 130 20039	BR100-03
GR1826	4822 130 30839	BY206 PH
GR1827	4822 130 30839	BY206 PH
GR1828	4822 130 30839	BY206 PH
GR1829	4822 130 30839	BY206 PH
GR1830	4822 130 30613	BAW62
GR1831	5322 130 34605	BAX12
GR1832	5322 130 34605	BAX12
GR1833	5322 130 34605	BAX12
GR1834	5322 130 34605	BAX12
GR1835	4822 130 30765	BZX75-C3V6
GR1836	5322 130 34605	BAX12
GR1837	5322 130 34605	BAX12
GR1838	5322 130 34605	BAX12
GR1839	5322 130 34605	BAX12
GR1841	5322 130 34605	BAX12
GR1842	5322 130 34605	BAX12
GR1843	5322 130 34605	BAX12
GR1844	5322 130 34605	BAX12
GR2401	4822 130 30613	BAW62
GR2601	4822 130 30613	BAW62
GR2801	4822 130 30613	BAW62

Transistors

ITEM	ORDERING NUMBER	TYPE/DESCRIPTION
TS101	5322 130 44797	ON471
TS102	5322 130 44459	BFT25R
TS103	5322 130 44606	BFR92R
TS202	5322 130 40417	BSX20
TS203	4822 130 40964	BC549
TS204	4822 130 40964	BC549
TS376	4822 130 44154	BF199
TS377	4822 130 40964	BC549
TS378	4822 130 41448	BF324
TS379	4822 130 44154	BF199
TS401	4822 130 40964	BC549
TS402	4822 130 41448	BF324
TS403	4822 130 41448	BF324
TS404	4822 130 40964	BC549
TS409	4822 130 40964	BC549
TS411	4822 130 40964	BC549
TS412	4822 130 40964	BC549
TS413	4822 130 40964	BC549
TS414	4822 130 40964	BC549
TS416	4822 130 40964	BC549
TS417	4822 130 40964	BC549
TS501	4822 130 40963	BC559
TS502	4822 130 40963	BC559
TS503	4822 130 40963	BC559
TS504	4822 130 40963	BC559
TS506	4822 130 44154	BF199
TS507	4822 130 40964	BC549
TS508	4822 130 44154	BF199
TS509	4822 130 41448	BF324
TS511	4822 130 40664	BD137
TS601	4822 130 41448	BF324
TS602	4822 130 41448	BF324
TS603	4822 130 40964	BC549
TS604	5322 130 40142	FW5324
TS606	5322 130 40673	FW5497
TS607	5322 130 40673	FW5497
TS608	5322 130 40142	FW5324
TS611	4822 130 44257	BC547
TS612	4822 130 44256	BC557
TS701	4822 130 44246	BC549C
TS702	4822 130 40963	BC559
TS703	4822 130 40963	BC559
TS704	4822 130 44154	BF199
TS705	4822 130 40964	BC549
TS706	4822 130 44154	BF199
TS707	4822 130 44154	BF199
TS708	4822 130 44154	BF199
TS709	4822 130 40854	BC327
TS751	4822 130 41448	BF324
TS752	4822 130 41448	BF324
TS761	4822 130 41448	BF324
TS762	4822 130 41448	BF324
TS771	4822 130 41448	BF324
TS772	4822 130 41448	BF324
TS781	4822 130 41448	BF324
TS782	4822 130 41448	BF324
TS791	4822 130 41448	BF324
TS792	4822 130 41448	BF324
TS801	4822 130 44246	BC549C
TS802	4822 130 40493	BFY90
TS803	4822 130 40964	BC549
TS804	4822 130 40493	BFY90
TS806	4822 130 40964	BC549
TS807	4822 130 40493	BFY90
TS808	4822 130 40493	BFY90
TS809	4822 130 40964	BC549
TS811	5322 130 44338	BFS17R
TS812	5322 130 40781	BFS17
TS851	5322 130 44338	BFS17R
TS852	5322 130 44743	BSR12
TS853	4822 130 40963	BC559
TS854	4822 130 40964	BC549
TS856	5322 130 40781	BFS17

ITEM	ORDERING NUMBER	TYPE/DESCRIPTION
TS857	5322 130 40781	BFS17
TS858	5322 130 44338	BFS17R
TS859	4822 130 40964	BC549
TS861	4822 130 40964	BC549
TS862	4822 130 40964	BC549
TS863	4822 130 40493	BFY90
TS864	4822 130 40963	BC559
TS865	4822 130 40964	BC549
TS866	4822 130 40963	BC559
TS867	4822 130 40963	BC559
TS868	5322 130 40417	BSX20
TS869	4822 130 40964	BC549
TS870	5322 130 40417	BSX20
TS871	4822 130 40963	BC559
TS872	4822 130 40964	BC549
TS873	4822 130 40964	BC549
TS874	4822 130 44246	BC549C
TS876	4822 130 44246	BC549C
TS877	4822 130 40964	BC549
TS878	4822 130 40964	BC549
TS879	4822 130 40964	BC549
TS881	4822 130 40964	BC549
TS882	4822 130 40964	BC549
TS883	4822 130 41448	BF324
TS884	4822 130 41448	BF324
TS886	4822 130 40963	BC559
TS887	4822 130 44246	BC549C
TS888	4822 130 44246	BC549C
TS1001	4822 130 40964	BC549
TS1002	4822 130 40493	BFY90
TS1003	4822 130 40964	BC549
TS1004	4822 130 40493	BFY90
TS1006	4822 130 40964	BC549
TS1007	4822 130 40493	BFY90
TS1008	4822 130 40493	BFY90
TS1009	4822 130 40964	BC549
TS1011	5322 130 40781	BFS17
TS1012	5322 130 44338	BFS17R
TS1051	5322 130 40781	BFS17
TS1052	5322 130 40781	BFS17
TS1053	5322 130 44338	BFS17R
TS1054	4822 130 40963	BC559
TS1056	5322 130 40781	BFS17
TS1057	4822 130 40963	BC559
TS1058	4822 130 40963	BC559
TS1059	4822 130 40964	BC549
TS1061	5322 130 40417	BSX20
TS1062	4822 130 40963	BC559
TS1063	4822 130 40964	BC549
TS1064	4822 130 40964	BC549
TS1066	4822 130 40964	BC549
TS1067	4822 130 40964	BC549
TS1068	4822 130 40963	BC559
TS1069	4822 130 40963	BC559
TS1071	4822 130 40964	BC549
TS1072	4822 130 40963	BC559
TS1201	4822 130 40964	BC549
TS1202	4822 130 40964	BC549
TS1203	4822 130 40964	BC549
TS1204	4822 130 40964	BC549
TS1206	5322 130 44127	2N2894A
TS1207	5322 130 44127	2N2894A
TS1208	4822 130 40908	BF336
TS1209	5322 130 44603	BFT45
TS1211	5322 130 44127	2N2894A
TS1212	5322 130 40417	BSX20
TS1213	4822 130 40908	BF336
TS1214	5322 130 44603	BFT45
TS1301	4822 130 40964	BC549
TS1302	5322 130 44127	2N2894A
TS1303	5322 130 40321	BSX21
TS1304	5322 130 40321	BSX21
TS1306	5322 130 40321	BSX21
TS1307	5322 130 40373	BCY71
TS1308	5322 130 40321	BSX21
TS1309	4822 130 40712	BD136
TS1311	4822 130 40712	BD136

ITEM	ORDERING NUMBER	TYPE/DESCRIPTION
TS1317	4822 130 40712	BD136
TS1401	5322 130 40373	BCY71
TS1402	5322 130 44788	BSW68
TS1801	5322 130 44357	BD262
TS1802	4822 130 44246	BC549C
TS1807	5322 130 44707	GESELECTEERD
TS1808	4822 130 44358	BC559B
TS1809	5322 130 44019	BSX60
TS1811	5322 130 40482	BRY39
TS1812	4822 130 44246	BC549C
TS1813	5322 130 44395	CNY43
TS2376	4822 130 44154	BF199
TS2377	4822 130 40964	BC549
TS2378	4822 130 41448	BF324
TS2379	4822 130 44154	BF199
TS2401	4822 130 40964	BC549
TS2402	4822 130 41448	BF324
TS2403	4822 130 41448	BF324
TS2404	4822 130 40964	BC549
TS2409	4822 130 40964	BC549
TS2411	4822 130 40964	BC549
TS2412	4822 130 40964	BC549
TS2413	4822 130 40964	BC549
TS2414	4822 130 40964	BC549
TS2416	4822 130 40964	BC549
TS2417	4822 130 40964	BC549
TS2576	4822 130 44154	BF199
TS2577	4822 130 40964	BC549
TS2578	4822 130 41448	BF324
TS2579	4822 130 44154	BF199
TS2601	4822 130 40964	BC549
TS2602	4822 130 41448	BF324
TS2603	4822 130 41448	BF324
TS2604	4822 130 40964	BC549
TS2609	4822 130 40964	BC549
TS2611	4822 130 40964	BC549
TS2612	4822 130 40964	BC549
TS2613	4822 130 40964	BC549
TS2614	4822 130 40964	BC549
TS2616	4822 130 40964	BC549
TS2617	4822 130 40964	BC549
TS2776	4822 130 44154	BF199
TS2777	4822 130 40964	BC549
TS2778	4822 130 41448	BF324
TS2779	4822 130 44154	BF199
TS2801	4822 130 40964	BC549
TS2802	4822 130 41448	BF324
TS2803	4822 130 41448	BF324
TS2804	4822 130 40964	BC549
TS2809	4822 130 40964	BC549
TS2811	4822 130 40964	BC549
TS2812	4822 130 40964	BC549
TS2813	4822 130 40964	BC549
TS2814	4822 130 40964	BC549
TS2816	4822 130 40964	BC549
TS2817	4822 130 40964	BC549

Integrated circuits

ITEM	ORDERING NUMBER	TYPE/DESCRIPTION
IC101	5322 209 85475	LM208H
IC102	5322 111 94032	TF CIRCUIT
IC201	5322 209 84823	SN74LS00N-00 TI
IC202	5322 209 84823	SN74LS00N-00 TI
IC203	5322 209 85486	SN74LS04N-00 TI
IC204	5322 209 84823	SN74LS00N-00 TI
IC206	5322 209 84986	SN74LS74N-00 TI
IC207	5322 209 84823	SN74LS00N-00 TI
IC208	5322 209 85265	SN74LS03N-00
IC209	5322 209 84986	SN74LS74N-00 TI
IC211	5322 209 84823	SN74LS00N-00 TI
IC212	5322 209 84823	SN74LS00N-00 TI
IC213	5322 209 85265	SN74LS03N-00
IC214	5322 209 84986	SN74LS74N-00 TI
IC216	5322 209 84823	SN74LS00N-00 TI
IC217	5322 209 85312	SN74LS02N-00 TI
IC401	5322 209 84355	OQ002
IC402	5322 209 84355	OQ002
IC501	5322 209 84355	OQ002
IC601	5322 209 84355	OQ002
IC602	5322 209 84355	OQ002
IC1301	5322 209 84452	UA709CH SC
IC1801	5322 209 84655	UA723CL PH
IC2401	5322 209 84355	OQ002
IC2402	5322 209 84355	OQ002
IC2601	5322 209 84355	OQ002
IC2602	5322 209 84355	OQ002
IC2801	5322 209 84355	OQ002
IC2802	5322 209 84355	OQ002

Miscellaneous

ITEM	ORDERING NUMBER	TYPE/DESCRIPTION
L 401	5322 281 64154	COIL
L 601	5322 466 14181	DELAY LINE COIL
L 1301	5322 150 14015	ROTARY COIL
L 1302	5322 526 14031	CHOKE BEAD
L 1303	5322 526 14031	CHOKE BEAD
L 1800	5322 281 64154	COIL
L 1803	5322 152 24027	
L 1804	5322 158 10052	COIL
L 1806	5322 281 64154	COIL
L 1807	5322 158 10052	COIL
L 1808	5322 281 64154	COIL
L 1809	5322 158 10052	COIL
L 1811	5322 281 64154	COIL
L 1812	5322 158 10052	COIL
L 1813	5322 281 64154	COIL
L 1814	5322 158 10052	COIL
L 1816	5322 281 64154	COIL
L 1817	5322 158 10052	COIL
L 1818	5322 281 64154	COIL
L 1819	5322 158 10052	COIL
L 1821	5322 281 64154	COIL
RE101	5322 280 24076	RELAY COIL
RE102	5322 280 24076	RELAY COIL
RE103	5322 280 24076	RELAY COIL
RE104	5322 280 24076	RELAY COIL
RE106	5322 280 24076	RELAY COIL
RE107	5322 280 24076	RELAY COIL
RE108	5322 280 24076	RELAY COIL
RE109	5322 280 24076	RELAY COIL
RE111	5322 280 24076	RELAY COIL
RE112	5322 280 24076	RELAY COIL
T 1401	5322 148 84023	TFE 3015
T 1801	5322 146 14069	TRAFO FXC
T 1802	5322 148 84026	FXC E42
RE101	5322 280 24126	GLASS TUBE RELAY CT.
RE102	5322 280 24126	GLASS TUBE RELAY CT.
RE103	5322 280 24126	GLASS TUBE RELAY CT.
RE104	5322 280 24126	GLASS TUBE RELAY CT.
RE106	5322 280 24126	GLASS TUBE RELAY CT.
RE107	5322 280 24126	GLASS TUBE RELAY CT.
RE108	5322 280 24126	GLASS TUBE RELAY CT.
RE109	5322 280 24126	GLASS TUBE RELAY CT.
RE111	5322 280 24126	GLASS TUBE RELAY CT.
RE112	5322 280 24126	GLASS TUBE RELAY CT.

Various electrical parts

ITEM	ORDERING NUMBER	TYPE/DESCRIPTION
B1	5322 131 24054	D14-125GH/37
B1	5322 131 24049	D14-125GM/08 (optional)
B1301	5322 131 90021	NEON TUBE
VL1	4822 253 30024	FUSE 1,6A T
FI 1801	5322 121 44261	MAINS FILTER
LA1	5322 134 44123	18V/40mA
LA2	5322 134 44123	18V/40mA

Units

ITEM	ORDERING NUMBER	TYPE/DESCRIPTION
UNIT 2	5322 105 44001	ATTENUATOR
UNIT 3	5322 121 44283	MAINS FILTER - used in PM 3244/05 and following versions).
UNIT 4	5322 320 44033	DELAY LINE
UNIT 5	5322 216 54116	POWER SUPPLY
UNIT 6	5322 216 54117	2KV CONVERTER
UNIT 8	5322 216 64258	TIME BASE-X AMPL .
UNIT 11	5322 216 54181	Z-AMPLIFIER
UNIT 12	5322 216 64261	INTERM. AMPLIFIER .
UNIT 13	5322 216 54122	FINAL Y AMPLIFIER .
UNIT 14	5322 216 64263	CHANNEL SEL. LOGIC .
UNIT 15	5322 218 64056	8KV EHT MULTIPLIER .
UNIG 16	5322 216 64262	TRIGGER SOURCE SEL .
UNIT 19	5322 216 64259	DELAY TIME CALIBRAT.
TS1804	5322 216 64257	SEL.TRANS.W.HEATSINK
TS1807	5322 130 44707	SEL.TRANS.W.BASERES.

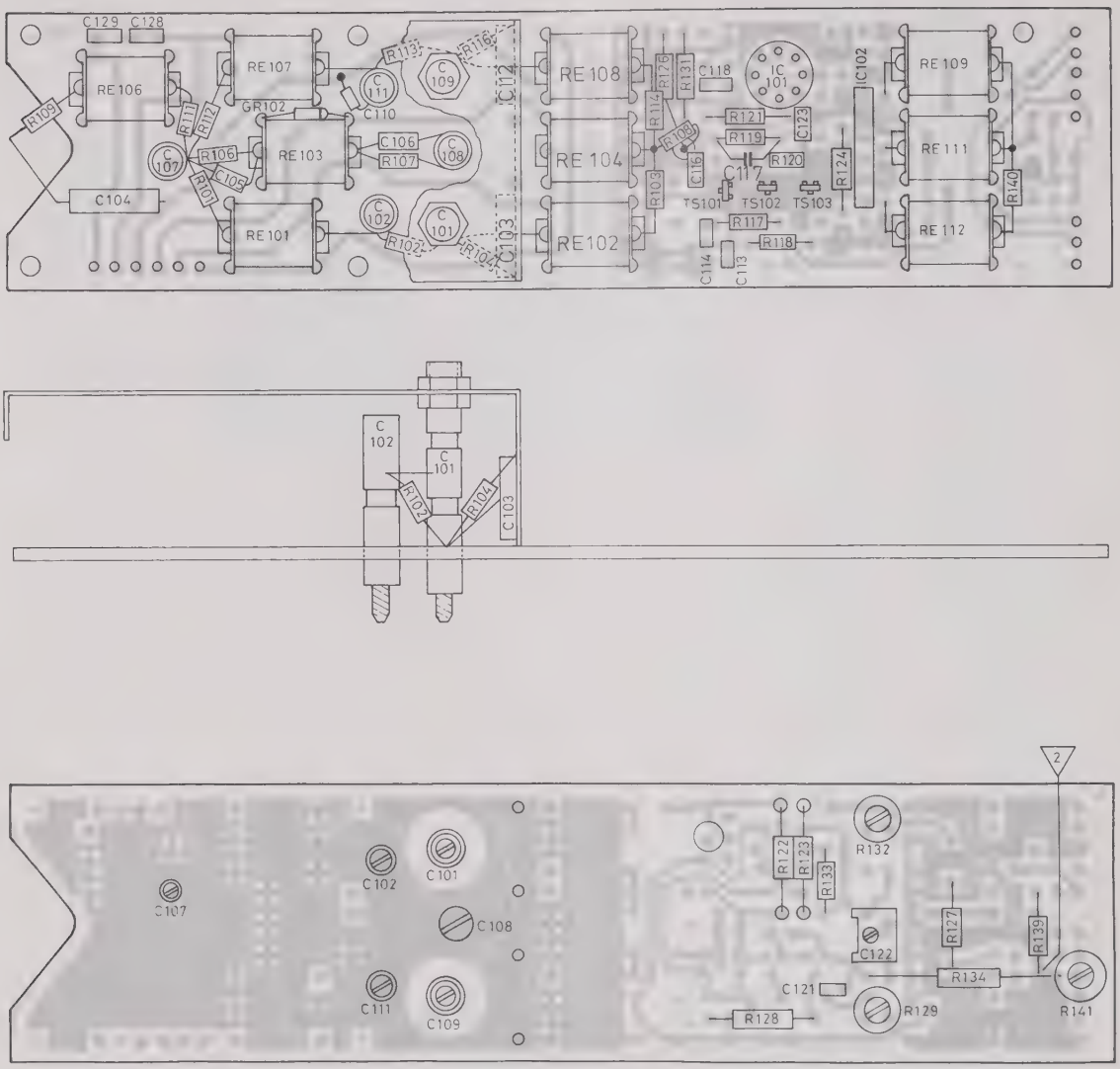

Fig. 3.16. Y-attenuator p.c.b (unit 2)

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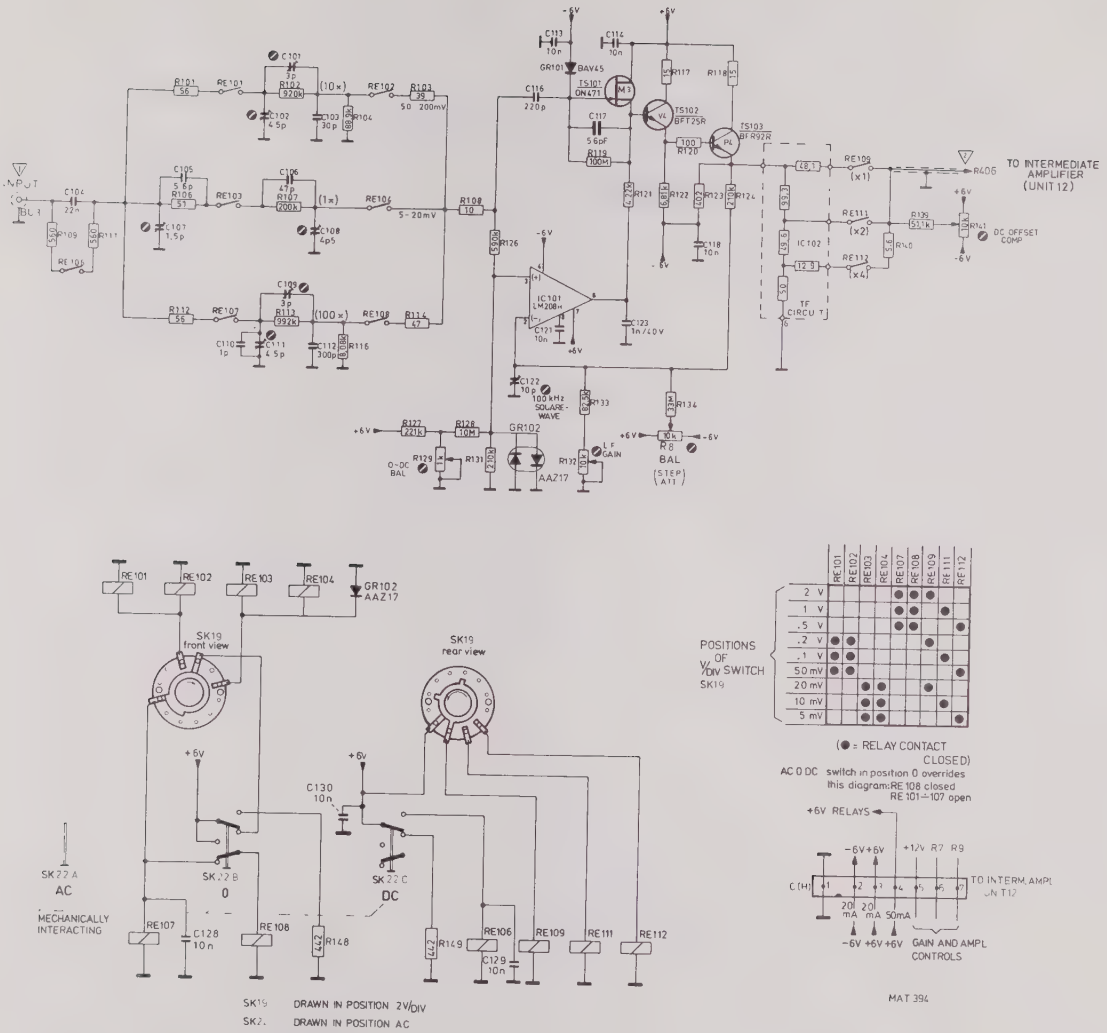


Fig. 3.17. Y-attenuator diagram (unit2)

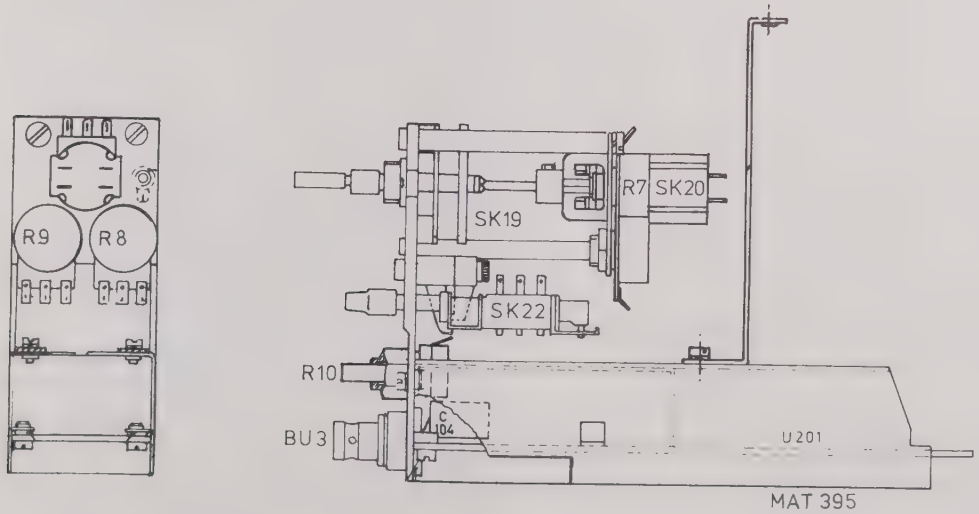


Fig. 3.18. Y-attenuator assembly

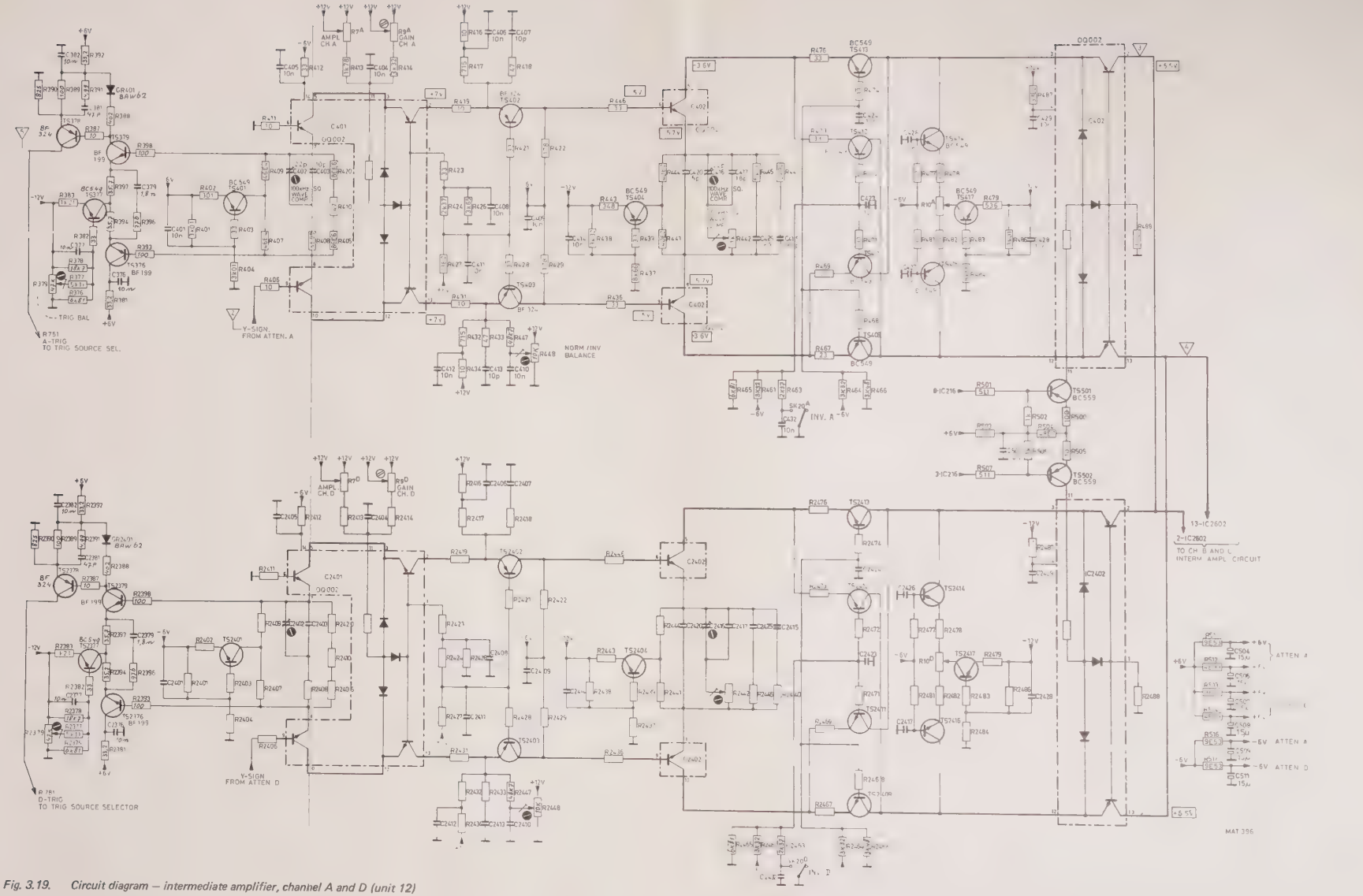


Fig. 3.19. Circuit diagram – intermediate amplifier, channel A and D (unit 12)

Note: The values of the items of channel A,B,C and D are equal.

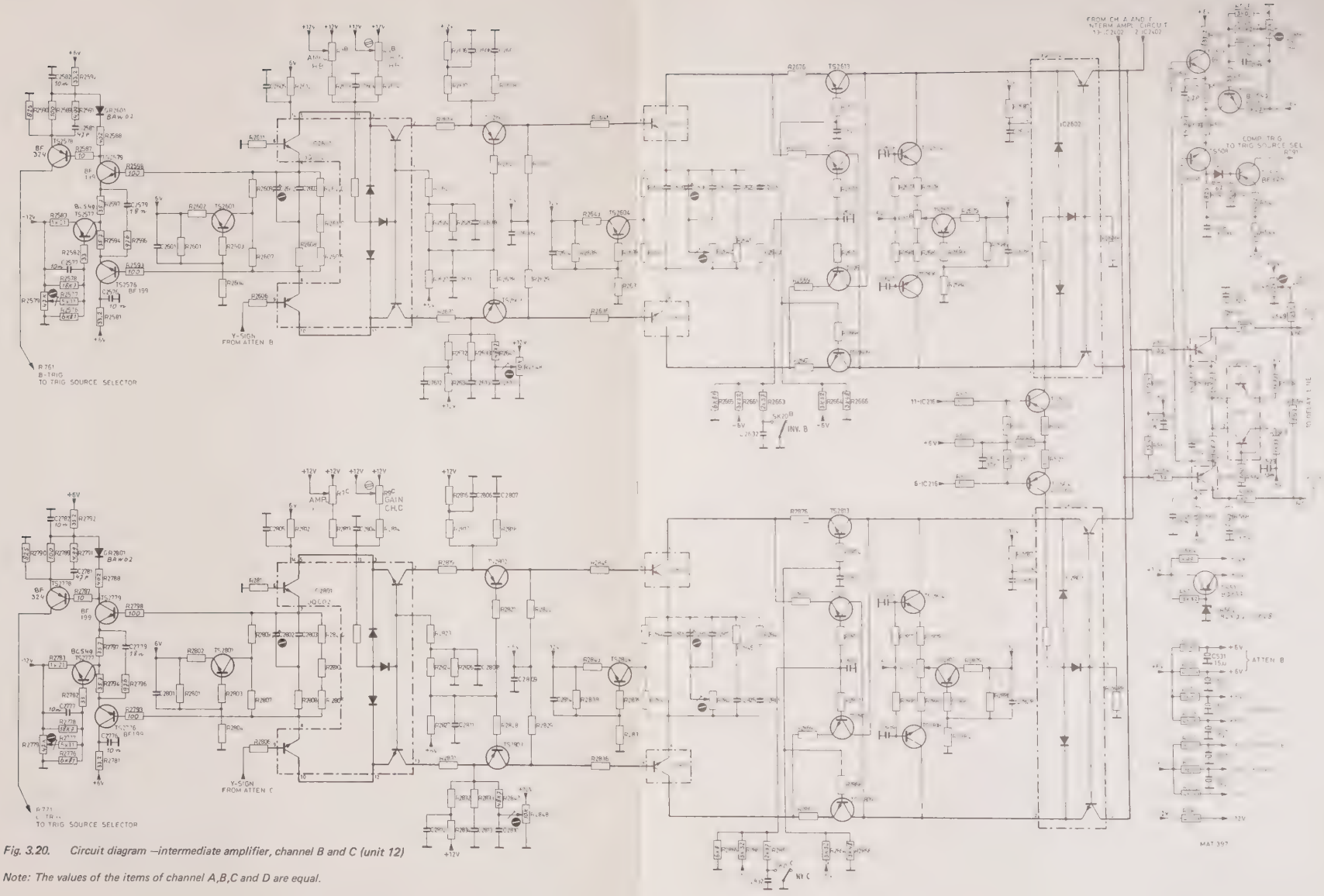

FROM CH A AND C INTERM AMPL CIRCUIT
Y-SIGN FROM ATTEN B
R761 B-TRIG TO TRIG SOURCE SELECTOR
INV. B
COMP. TR G TO TRIG SOURCE SEL
TO DELAY LINE
ATTEN B
Y-SIGN FROM ATTEN C
R721 L-TRIG TO TRIG SOURCE SELECTOR
INV. C
MAT 397

Fig. 3.20. Circuit diagram –intermediate amplifier, channel B and C (unit 12)

Note: The values of the items of channel A,B,C and D are equal.

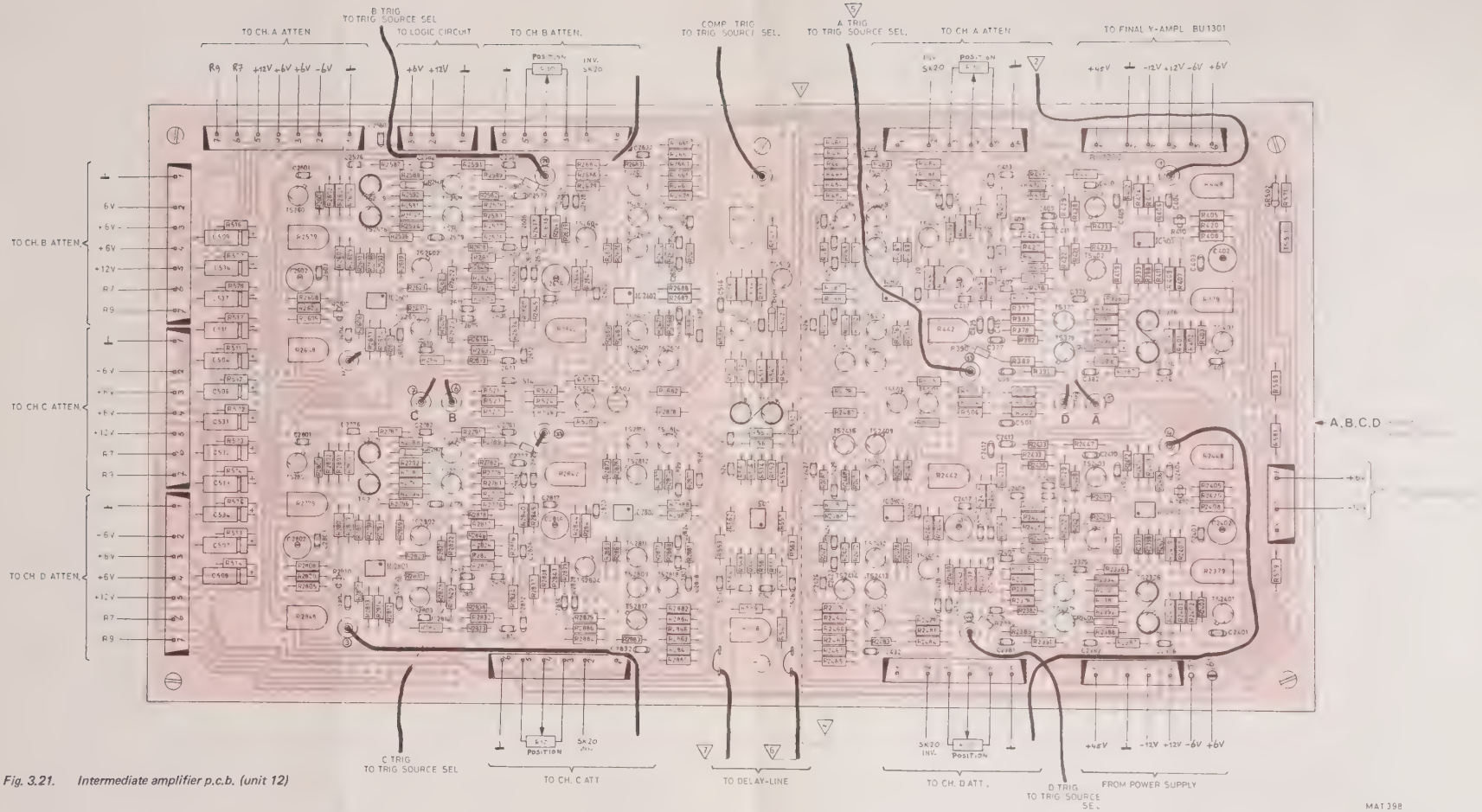


Fig. 3.21. Intermediate amplifier p.c.b. (unit 12)

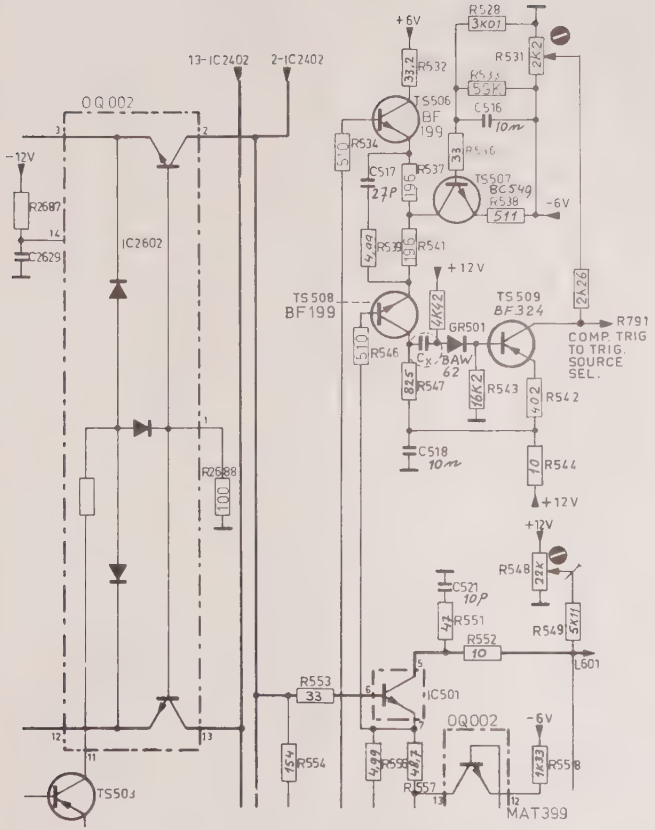


Fig. 3.22. Modified circuit for A.C. composite triggering (unit 12)

Fig. 3.23. Modified circuit lay out for A.C. composite triggering

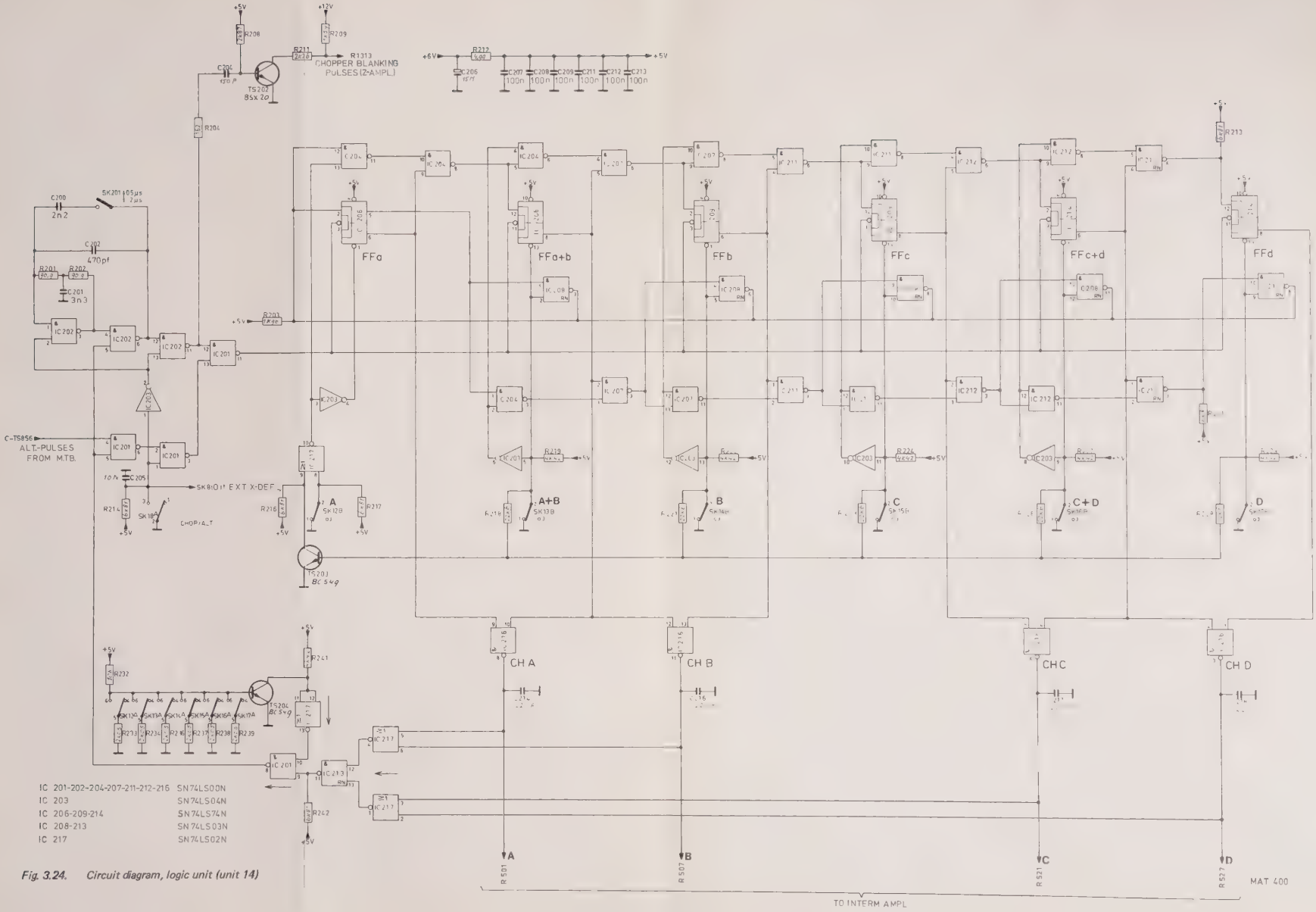


Fig. 3.24. Circuit diagram, logic unit (unit 14)

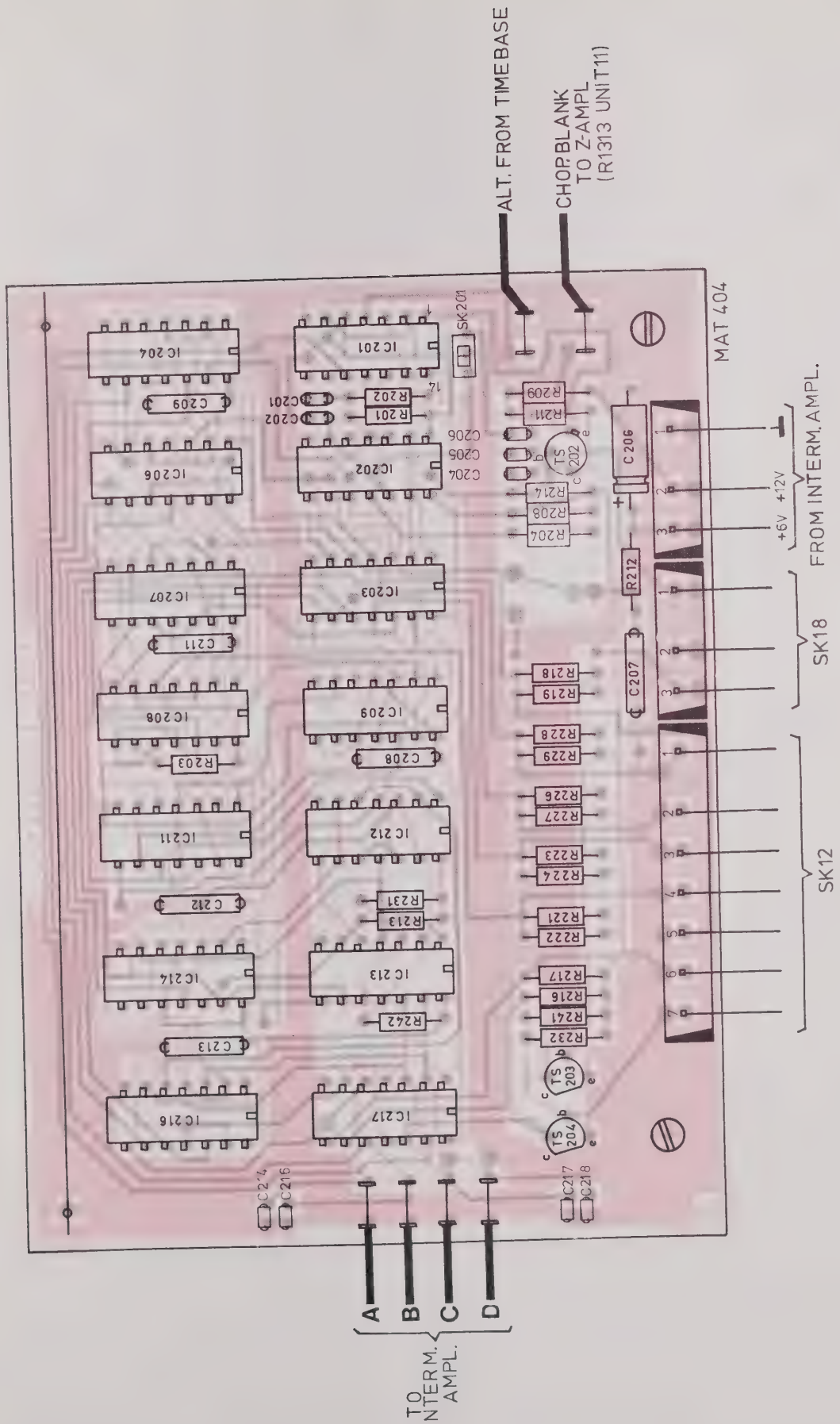


Fig. 3.25. Components lay out, logic unit (unit 14)

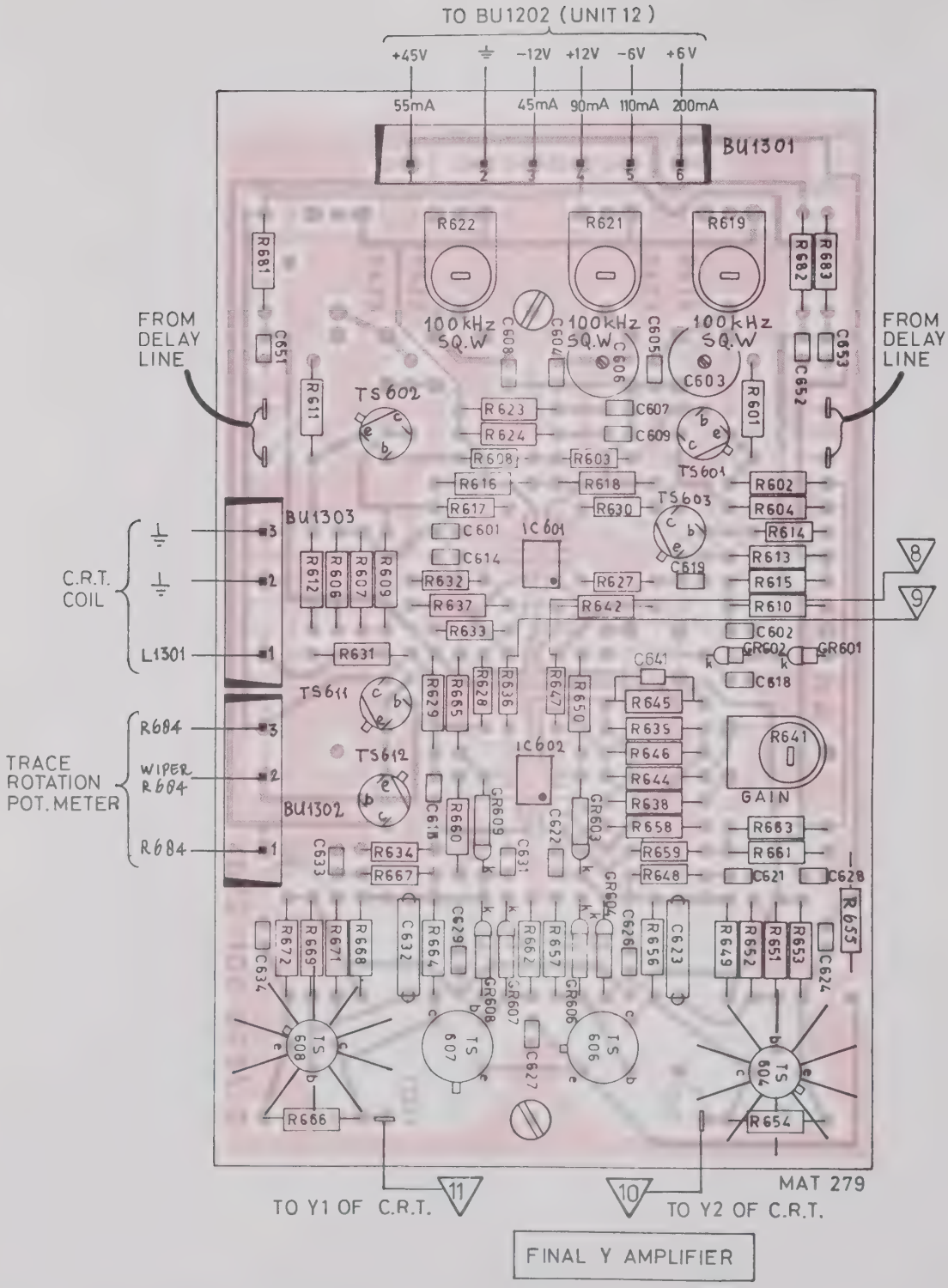


Fig. 3.26 Final Y amplifier p.c.b. (unit 13)

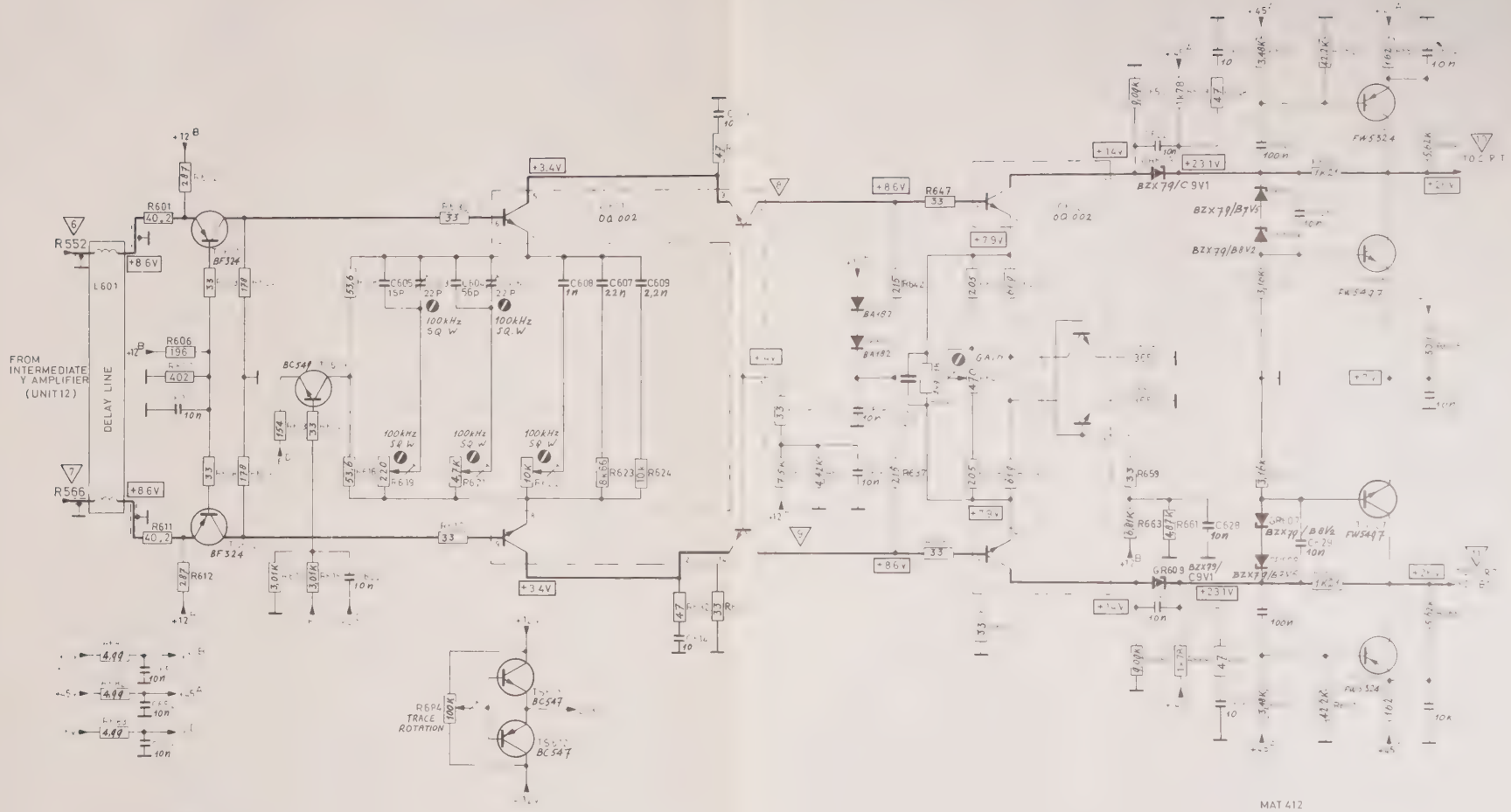


Fig. 3.27. Circuit diagram, final Y-amplifier (unit 13)

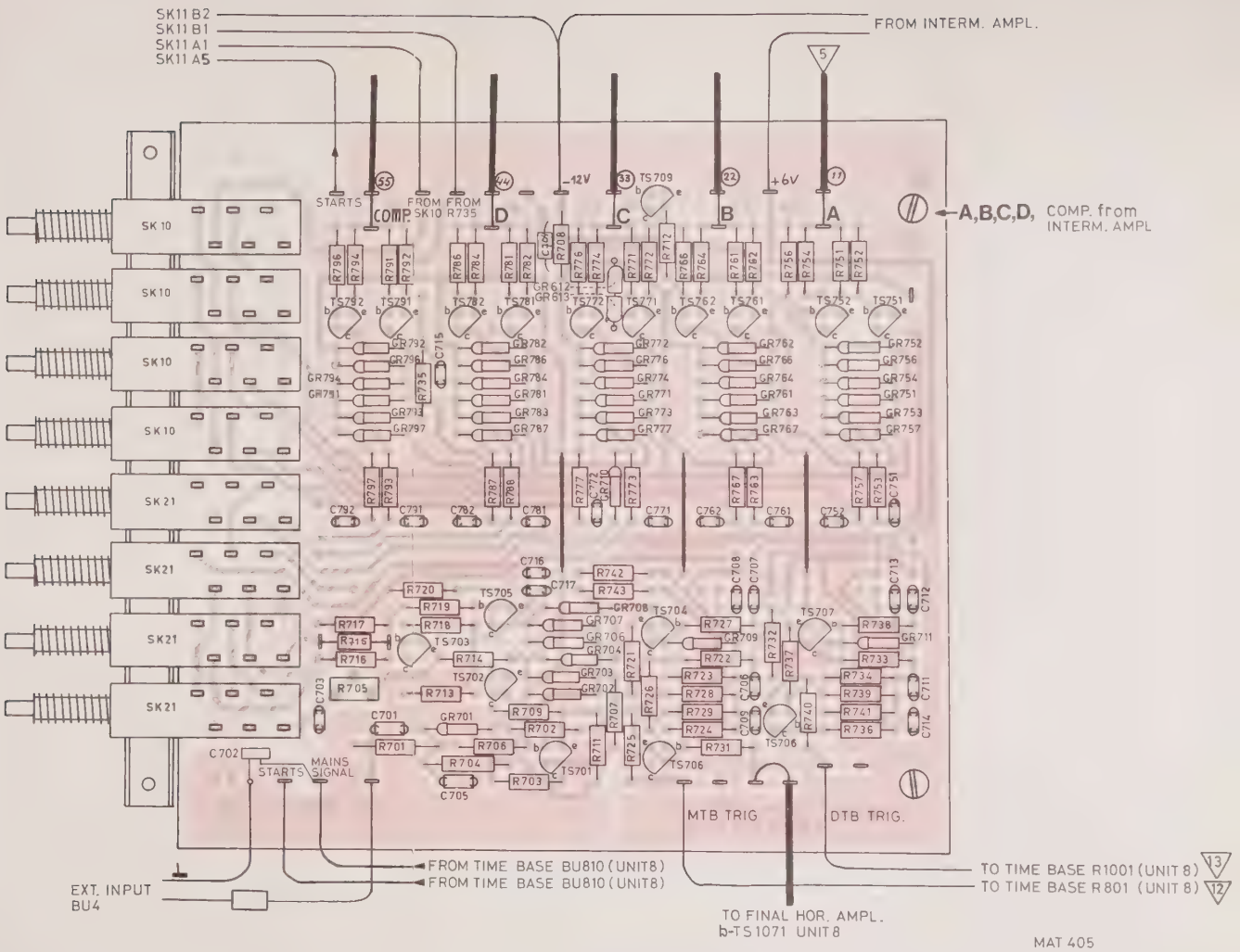


Fig. 3.28. Components lay out , trigger source selector (unit 16)

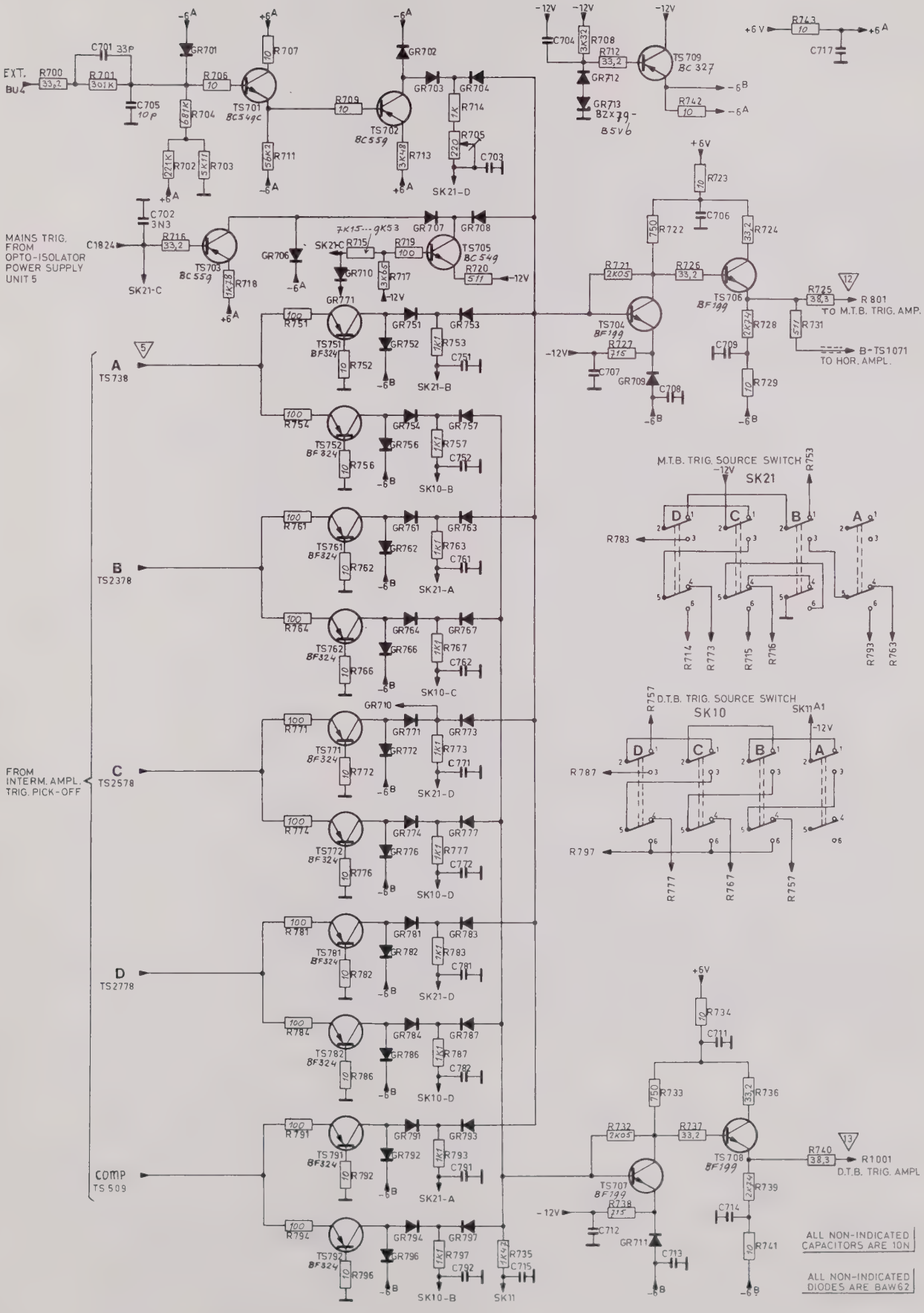
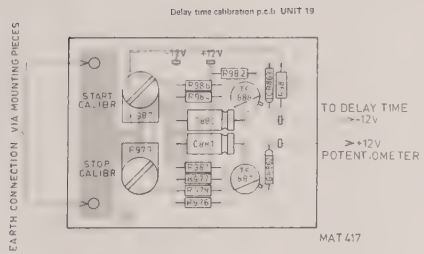


Fig. 3.29. Circuit diagram, trigger source selector (unit 16)



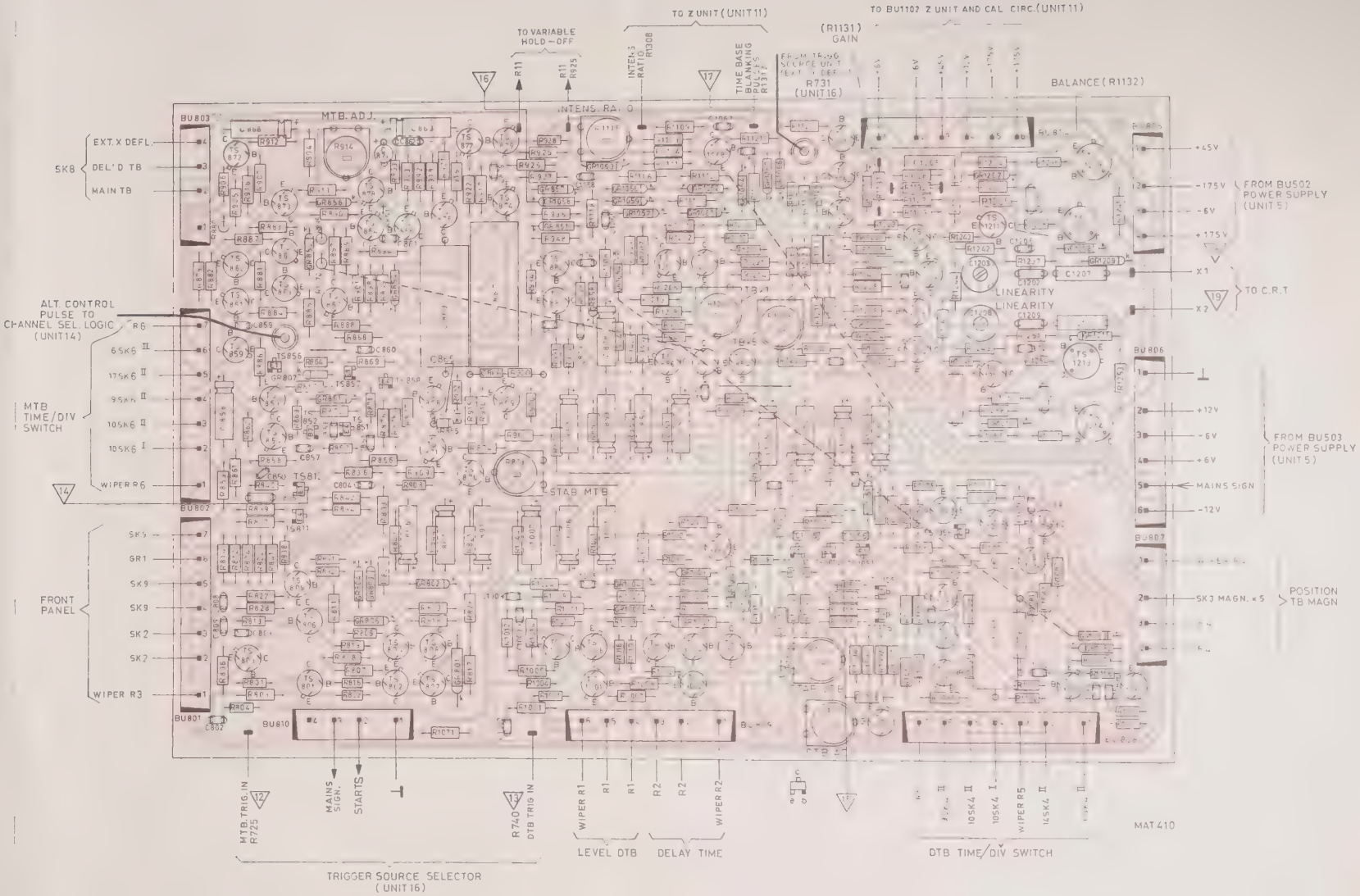


Fig. 3.30. *Time base X-amplifier and calibration p.c.b. (unit 8 and 19)*

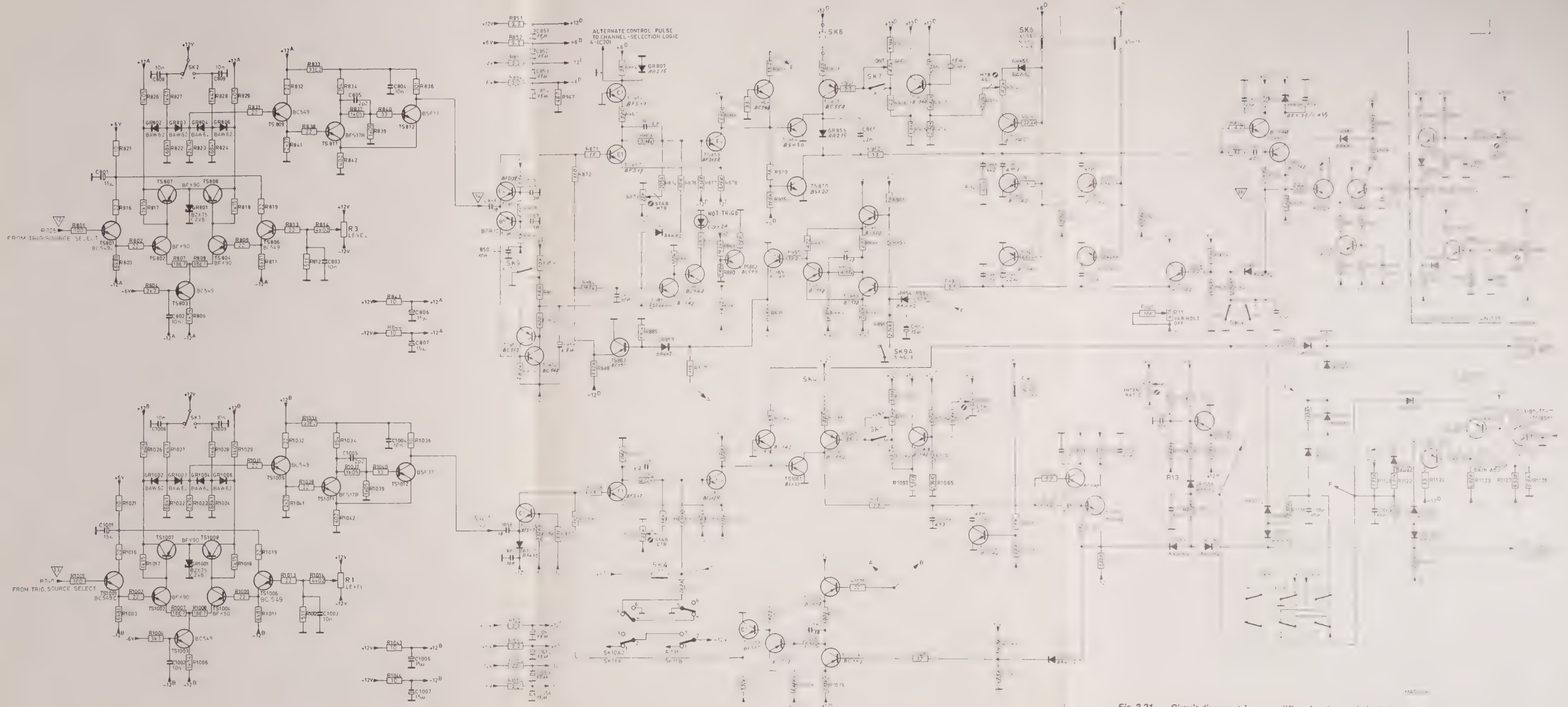


Fig. 3.31. Circuit diagram, trigger amplifier, time base unit (unit 8) and delay-time calibration unit (unit 19)

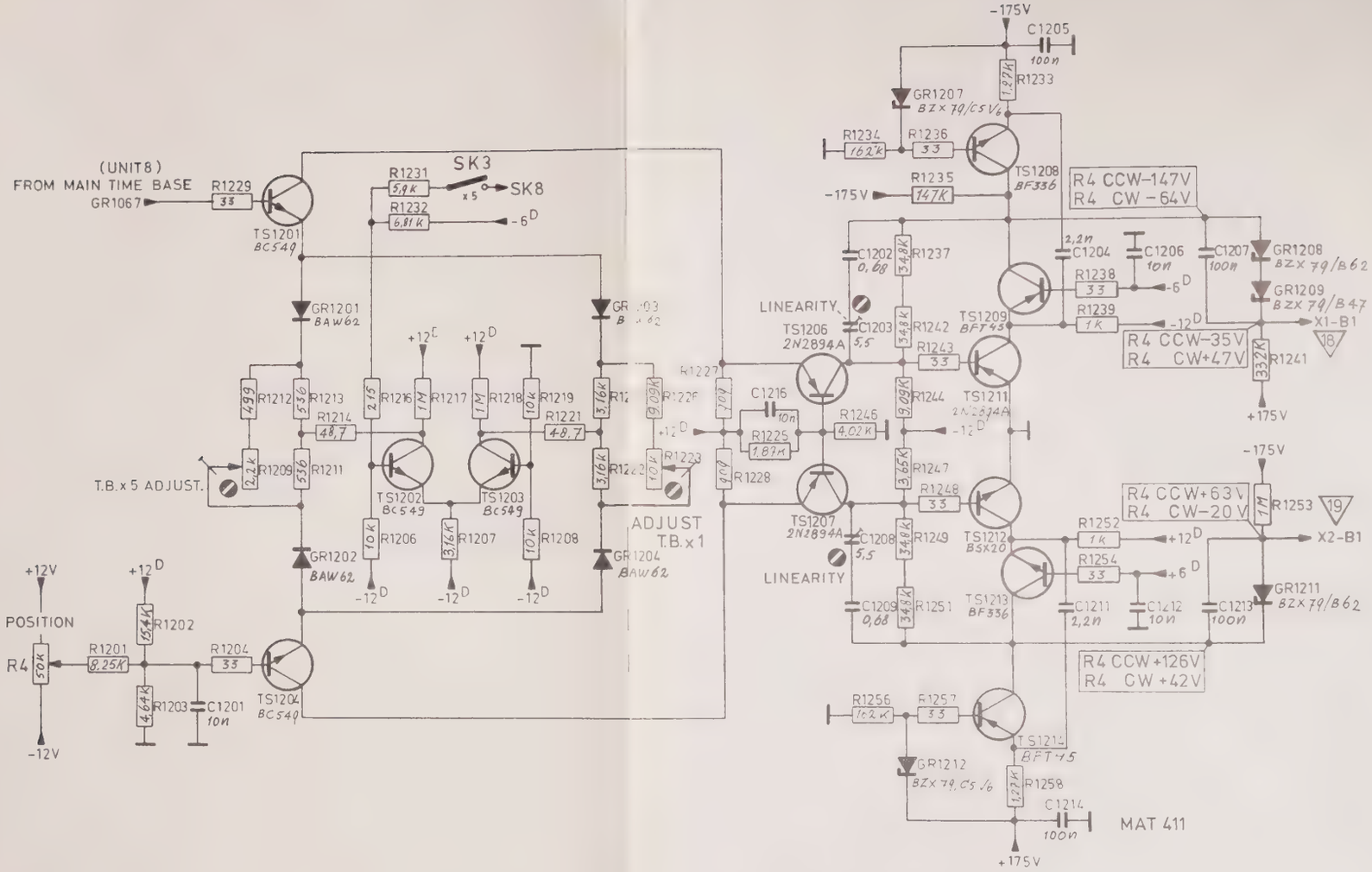
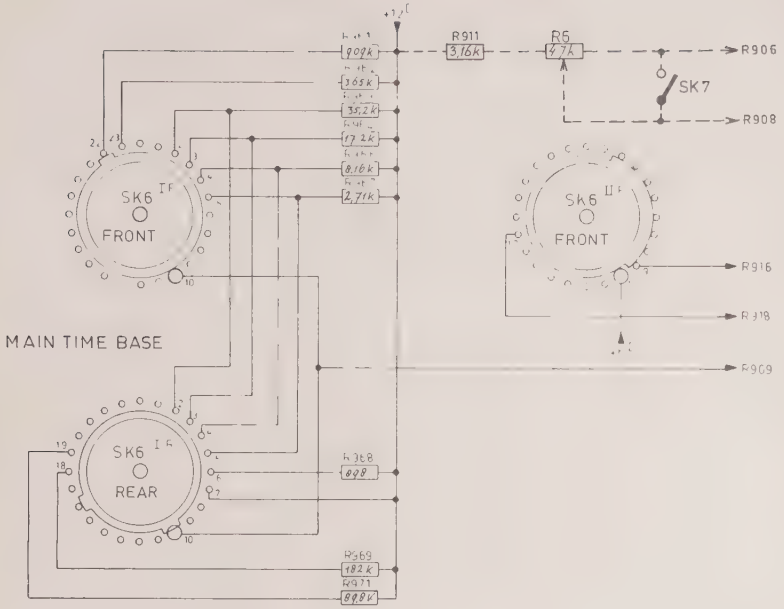
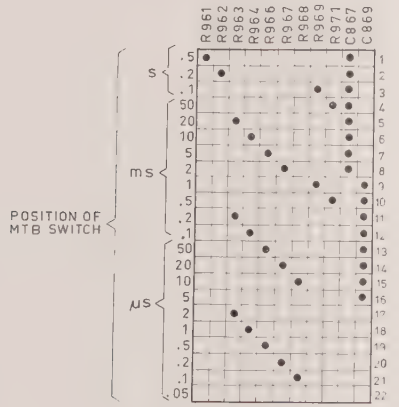


Fig. 3.32. Circuit diagram, X-amplifier (unit 8)

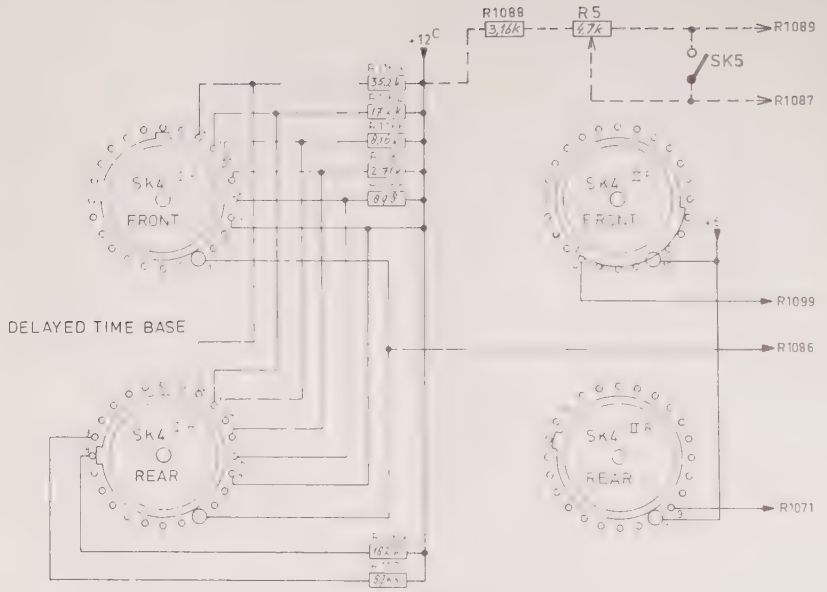


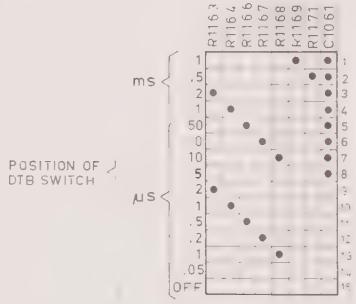


TIME BASE CAPACITOR AND CURRENT SOURCE RESISTOR TO BE ACTIVE AS A FUNCTION OF THE MTB KNOB POSITION

MAT 413

Fig. 3.33. Mains time base switch





TIME BASE CAPACITOR AND CURRENT SOURCE RESISTOR TO BE ACTIVE AS A FUNCTION OF THE DTB KNOB POSITION

MAT 414

Fig. 3.34. Delayed time base switch

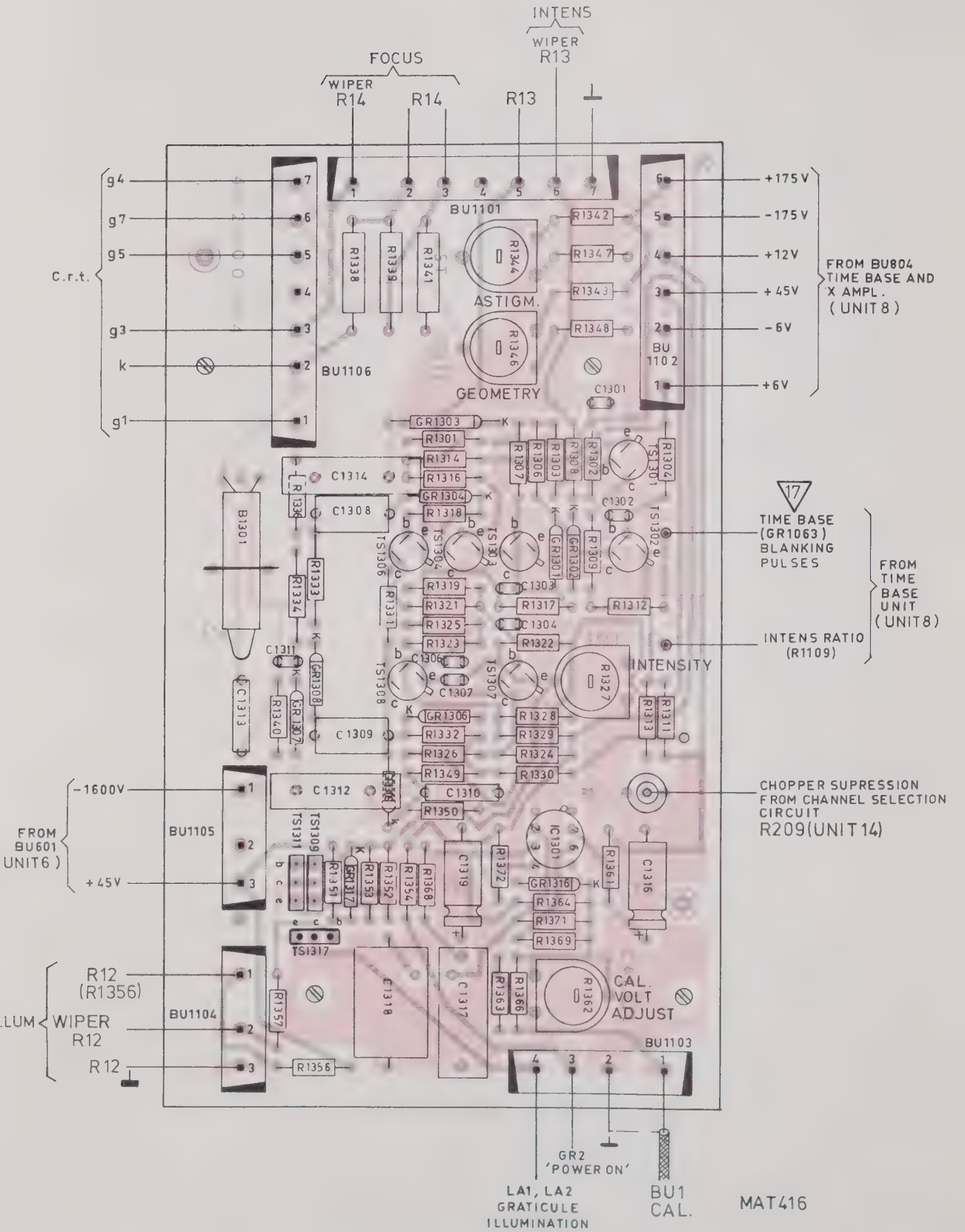


Fig. 3.35. Z-unit , illumination and calibration unit (unit 11)

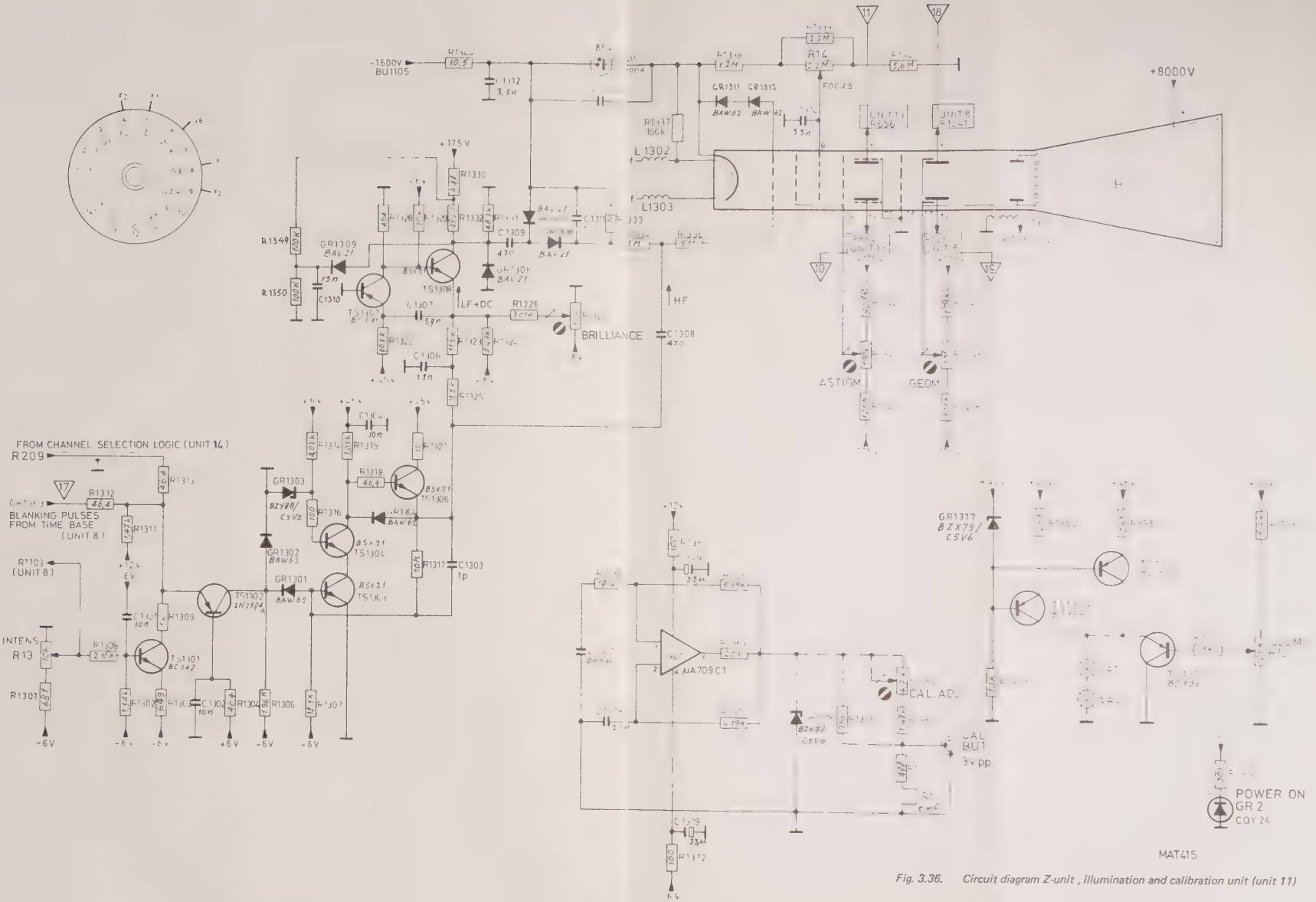


Fig. 3.36. Circuit diagram Z-unit , illumination and calibration unit (unit 11)

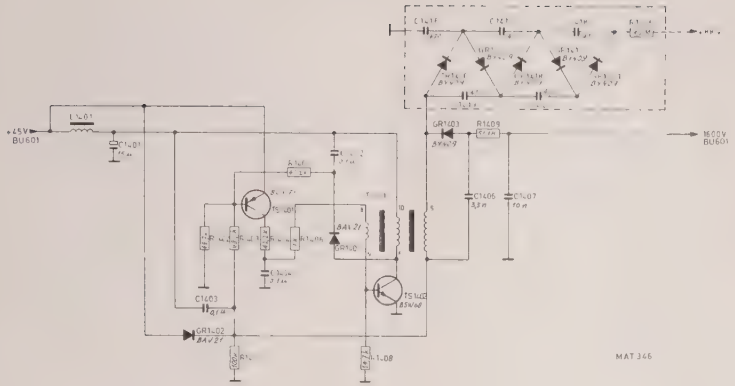


Fig. 3.38. Circuit diagram EHT converter (unit 6 and 15)

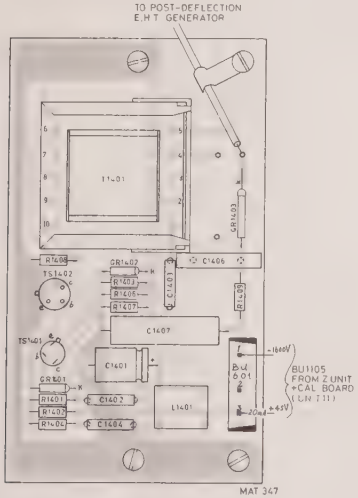
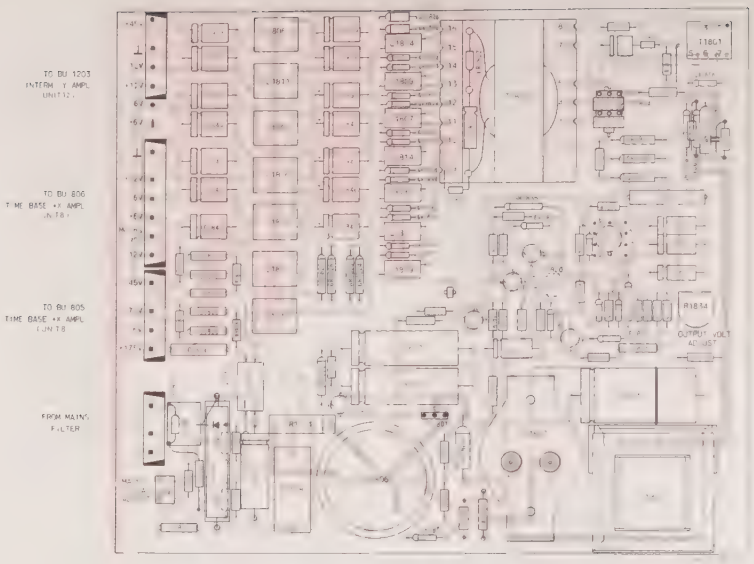


Fig. 3.39. EHT converter p.c.b. (unit 6)



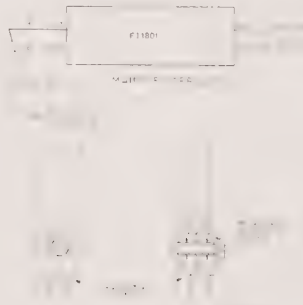


Fig. 3.37. Power supply p.c.b. (unit 5)

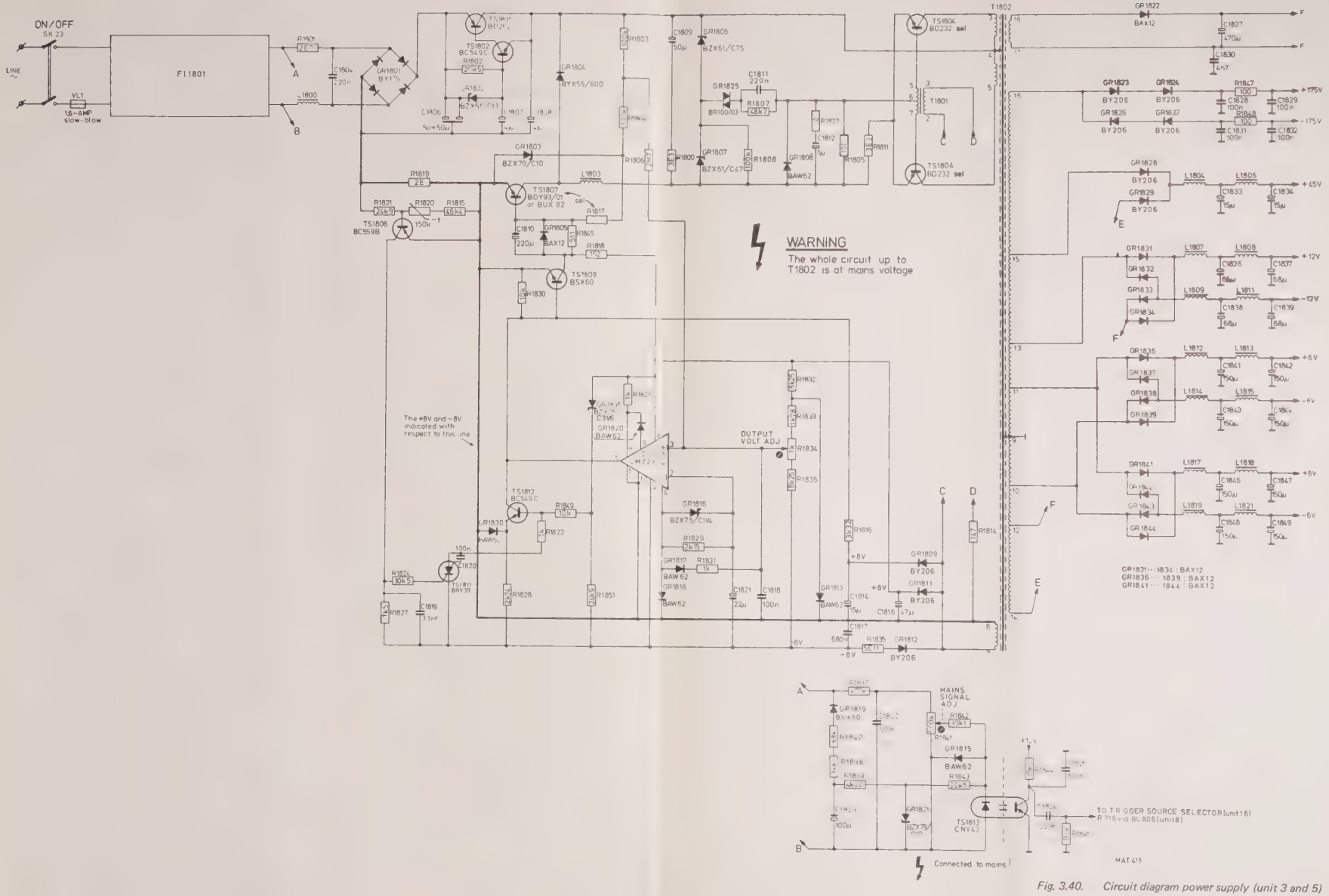


Fig. 3.40. Circuit diagram power supply (unit 3 and 5)

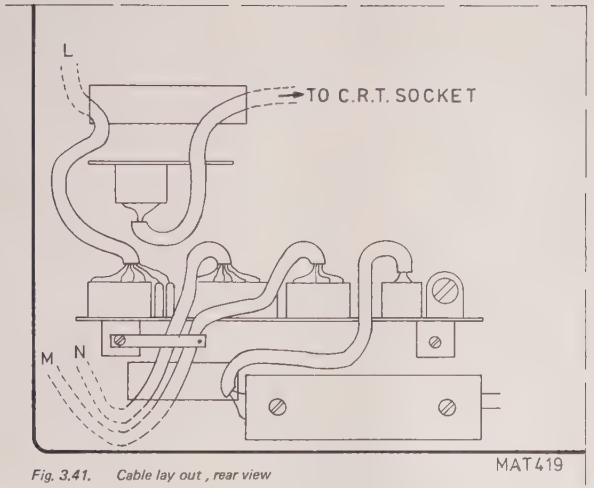


Fig. 3.41. Cable lay out , rear view

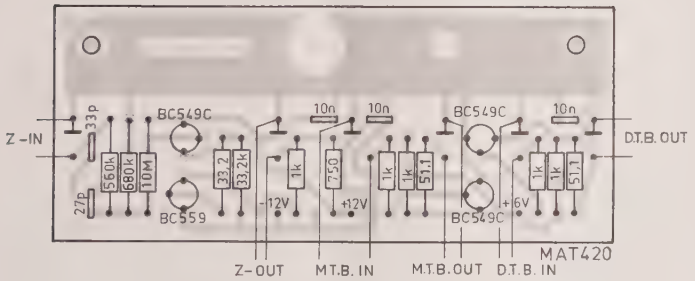


Fig. 3.42. Lay out additional p.c.b.

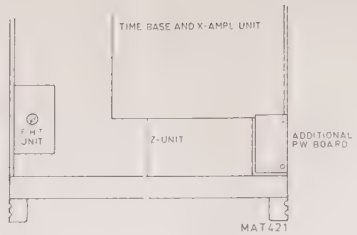


Fig. 3.43. Location of the additional p.c.b.

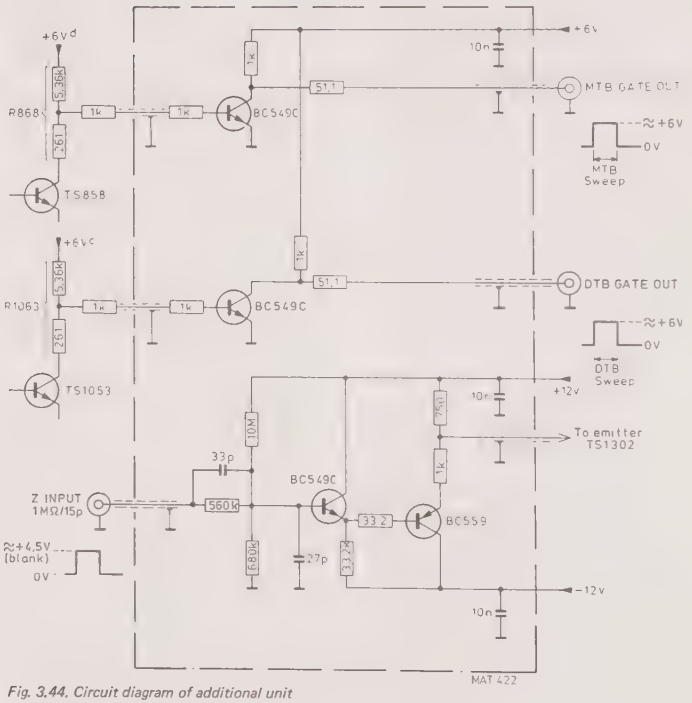


Fig. 3.44. Circuit diagram of additional unit

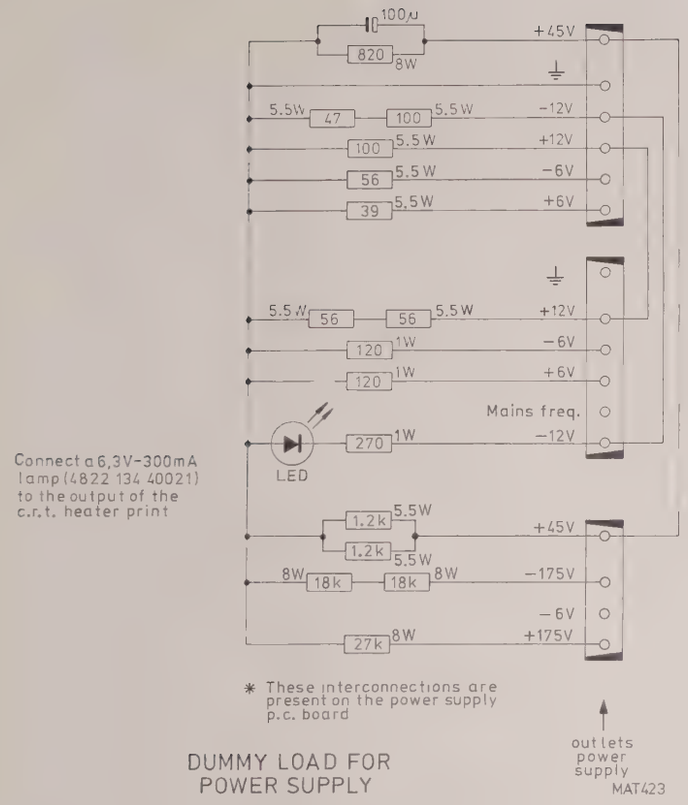


Fig. 3.45. Dummy load for power supply

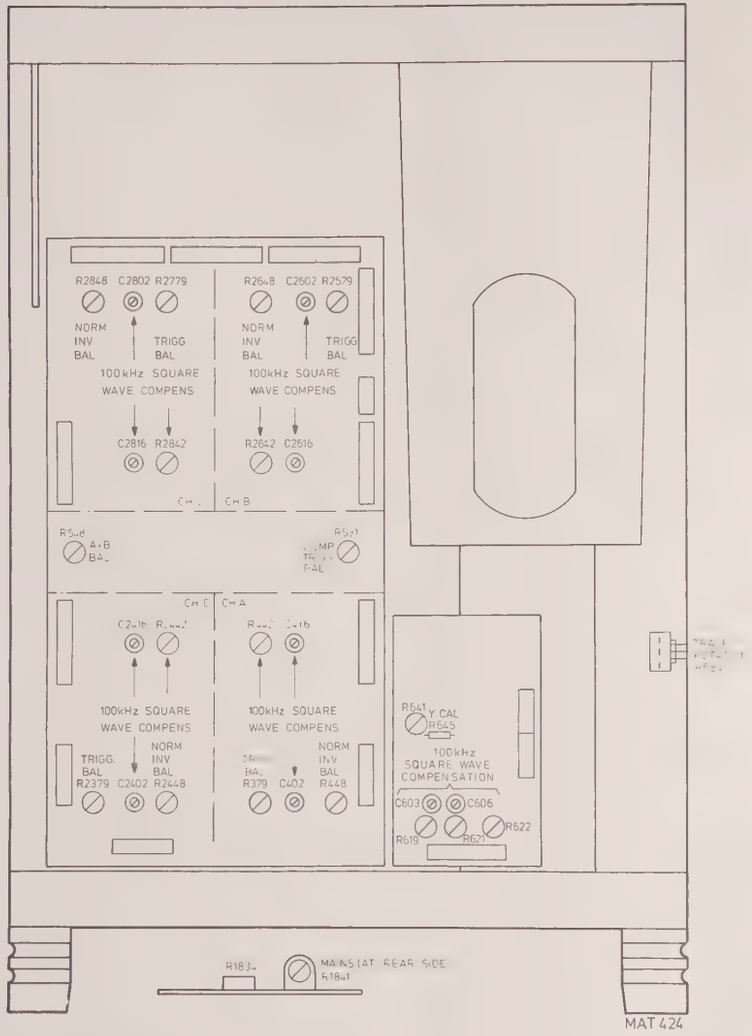


Fig. 3.46. Adjustment points, top view

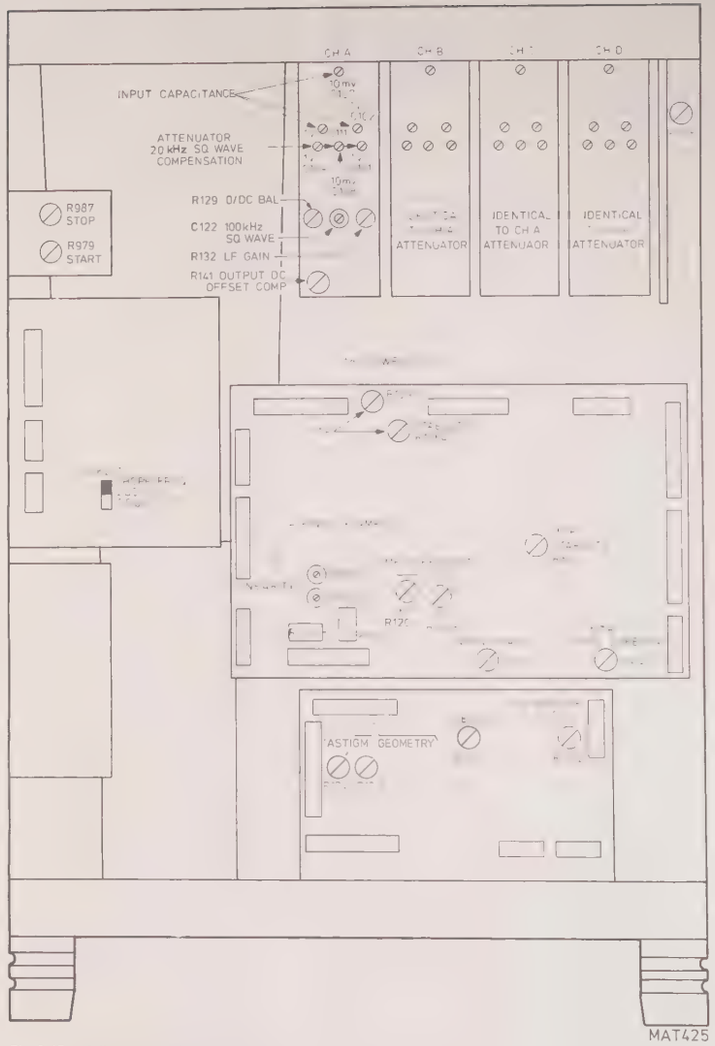


Fig. 3.47. Adjustment points, bottom view

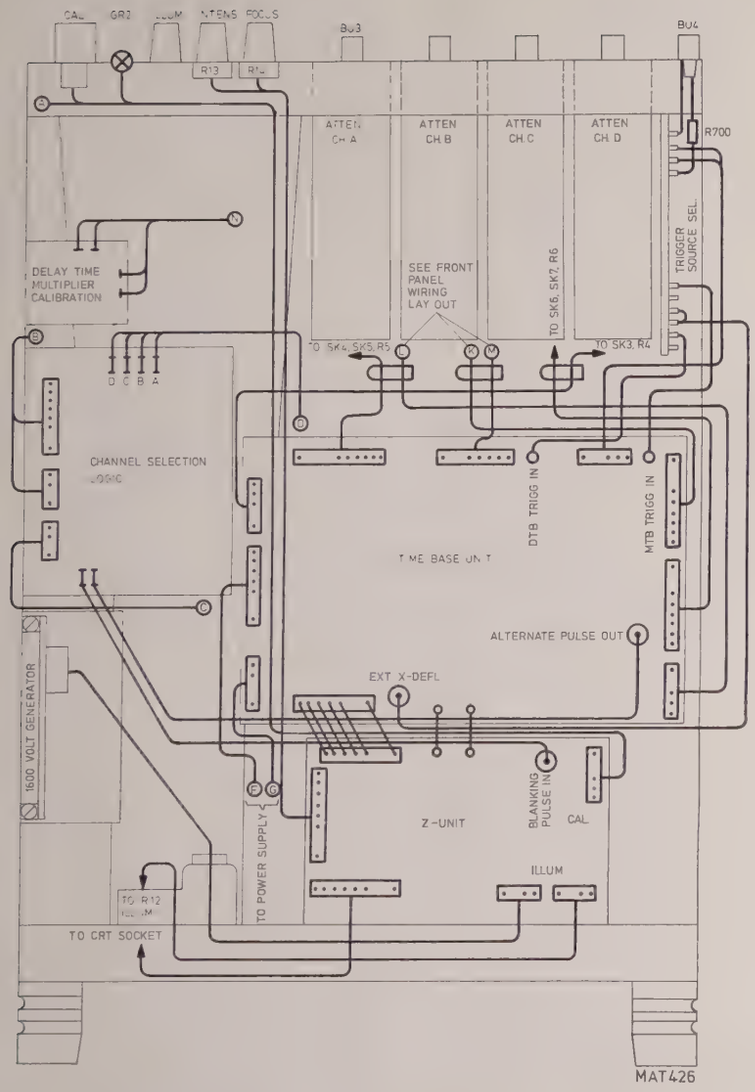


Fig. 3.48. Cable lay-out , bottom view

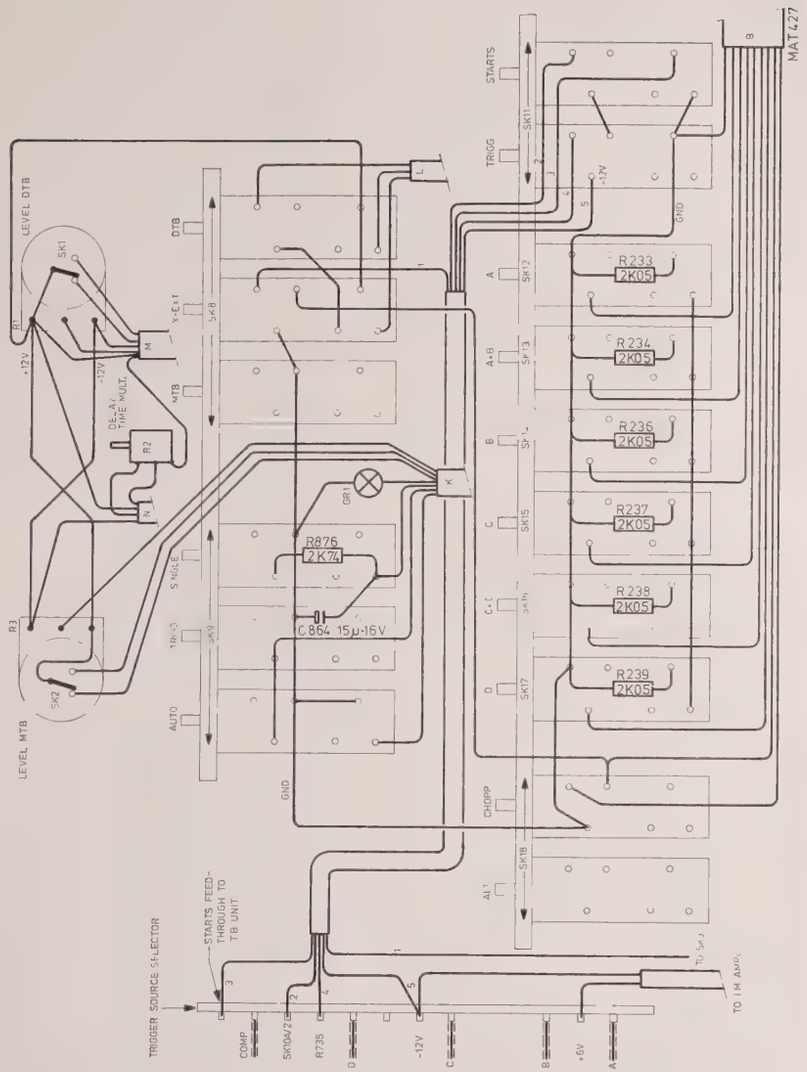


Fig. 3.49. Wiring lay-out , front panel

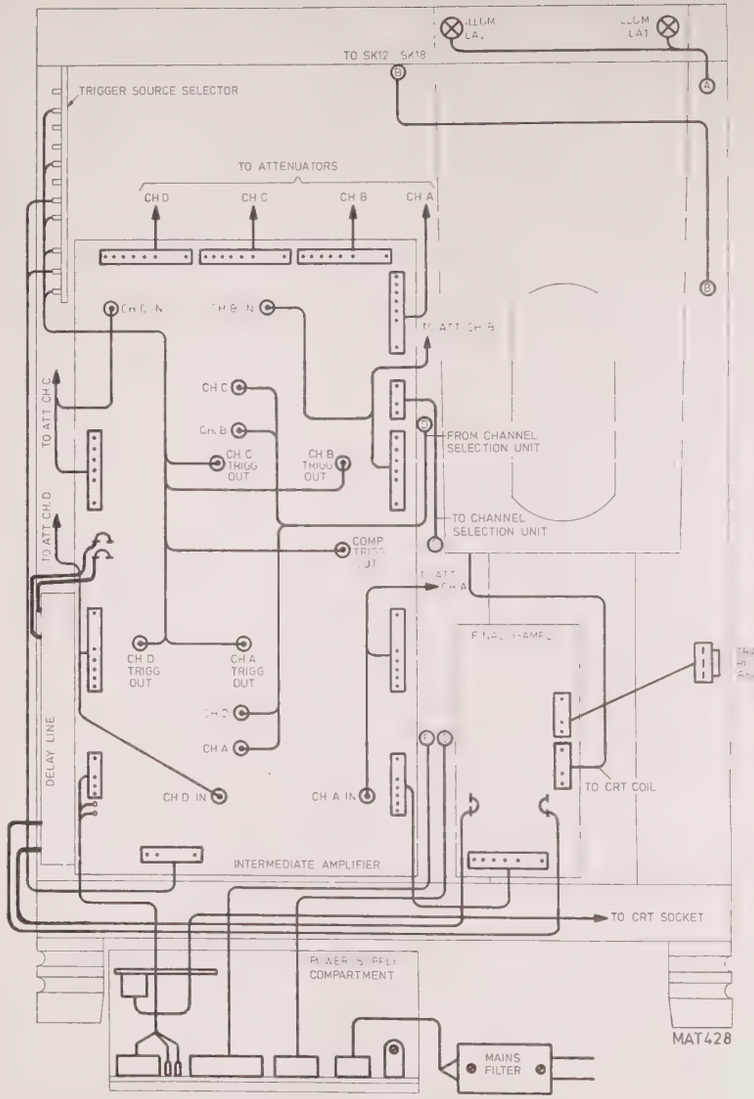


Fig. 3.50. Cable lay-out, top view and power supply compartment

3.9. D.C. VOLTAGES AND WAVEFORMS

The d.c. voltage levels and waveforms at the relevant points in the circuitdiagrams are measured with the following control settings:

- Set all push-buttons in their not-depressed position.
- Depress push-button A of the vertical display mode switch (SK12);
- Depress push-button AUTO of the m.t.b. trigger mode switches (SK9).
- Depress push-button MAIN TB of the horizontal display mode switch (SK8).
- Set the horizontal POSITION control (R4) at mid-range and TB MAGN to 1X.
- Set the trace in the middle of the screen with the vertical POSITION Control (R10).
- Depress push-button A of the m.t.b. trigger source selector (SK21).
- Set the m.t.b. TIME/DIV. switch (SK6) to 0,2 msec/div. and R6 to CAL.
- Depress push-button AC of the signal input coupling switch (SK22).
- Set the d.t.b. TIME/DIV switch (SK4) to OFF and R5 to CAL.
- Set the channel A AMPL/DIV switch to 1 V/DIV and potentiometer R7 to CAL.
- Push the m.t.b. SLOPE switch (SK2) to +.
- Push the d.t.b. SLOPE switch (SK1) to +.
- Depress push-button A of the d.t.b. trigger source selector (SK10).
- Depress push-button STARTS of the d.t.b. switch SK11.
- Apply a square wave signal of 6 V pp, frequency 1 kHz to input socket A (BU3).
- Adjust the m.t.b. LEVEL potentiometer R3 for a stable, triggered display.

ATTENTION:

- As the four channels A, B, C and D are completely identical only the signals of channel A are measured.
- The oscilloscope for measuring the wafevorms has the following control settings:
  - AC input signal coupling unless otherwise stated.
  - Triggered on the positive going slope of the input signal.

AUXILIARY EQUIPMENT:

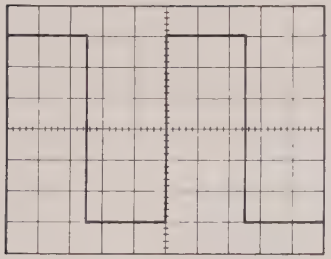
Digital multimeter	e.g. Philips PM 2517 or PM 2527
Oscilloscope	e.g. Philips PM 3262 with an attenuator probe 10 : 1
Function generator	e.g. Philips PM 5127

UNIT 2

1

0,1 V/div

0,2 m sec/div



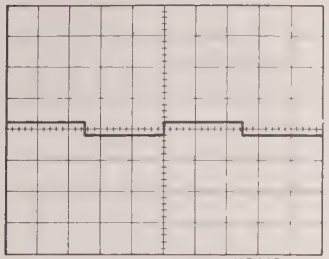
MAT 439

UNIT 12

2

5 mV/div

0,2 m sec/div



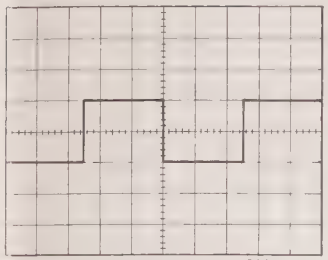
MAT 440

UNIT 12

3

5 mV/div

0,2 m sec/div



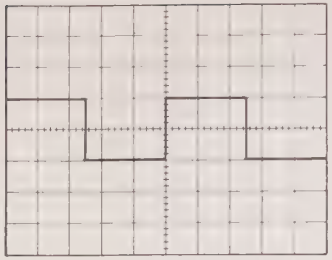
MAT 441

UNIT 12

4

5 mV/div

0,2 m sec/div



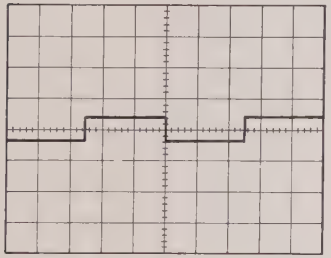
MAT 442

UNIT 16

5

5 mV/div

0,2 m sec/div



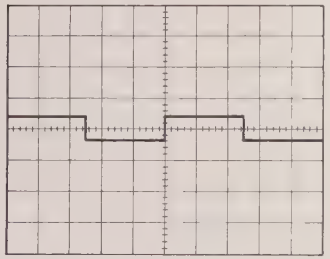
MAT 443

UNIT 12

6

5 mV/div

0,2 m sec/div



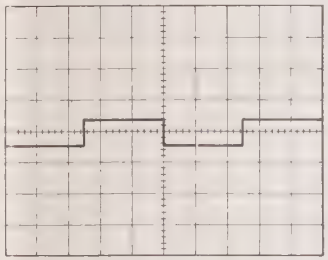
MAT 444

UNIT 12

7

5 mV/div

0,2 m sec/div



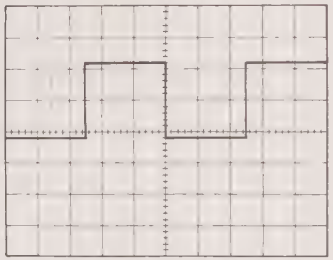
MAT 445

UNIT 13

8

20 mV/div

0,2 m sec/div



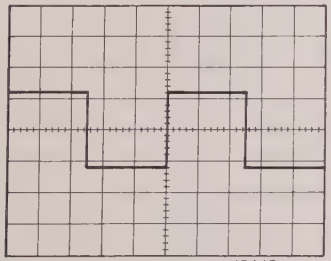
MAT 446

UNIT 13

9

20 mV/div

0,2 m sec/div



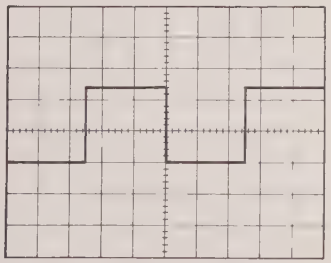
MAT 447

UNIT 13

10

0,5 V/div

0,2 m sec/div



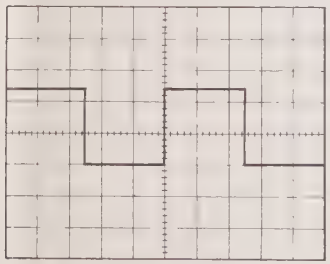
MAT 448

UNIT 13

11

0,5 V/div

0,2 m sec/div



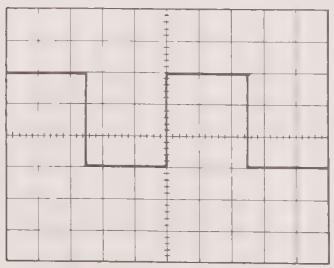
MAT 449

UNIT 16

12

20 mV/div

0,2 m sec/div

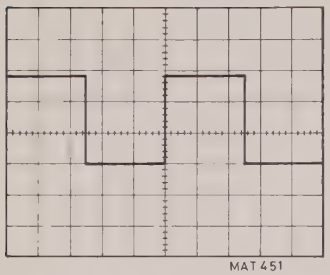


MAT 450

UNIT 16

13

20 mV/div 0,2 m sec/div



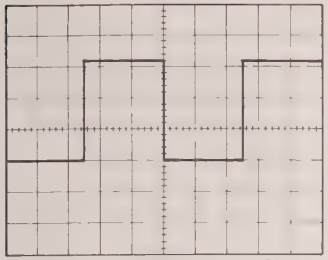
MAT 451

– push-button TRIG. (D.T.B.) depressed
– push-button STARTS (D.T.B.) depressed → 1,8 V d.c.

UNIT8

14

0,1 V/div 0,2 m sec/div

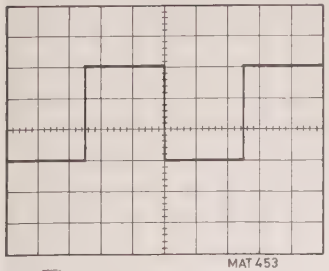


MAT 452

UNIT 8

15

0,1 V/div 0,2 m sec/div



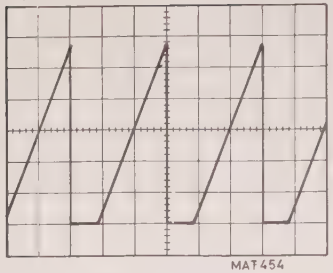
MAT 453

– push-button TRIG. (D.T.B.) depressed
– D.T.B. LEVEL potentiometer in its mid-position
– push-button STARTS (D.T.B.) depressed → 8Vd.c.

UNIT 8

16

0,1 V/div 1 m sec/div



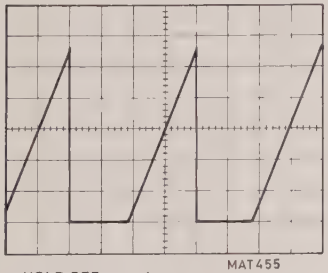
MAT 454

– M.T.B. TIME/DIV switch to 0,2 m sec/div
– HOLD OFF potentiometer fully clockwise

UNIT 8

18

2 V/div 1 m sec/div



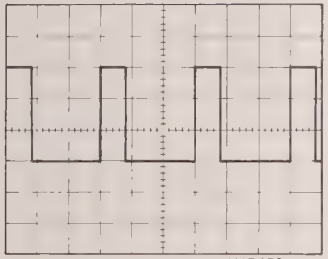
MAT 455

– HOLD OFF potentiometer counter-clockwise

UNIT 8

17

5 mV/div 1 m sec/div



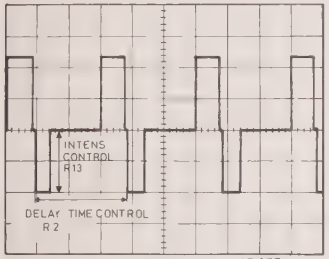
MAT 456

– D.T.B. TIME/DIV switch to OFF

UNIT 8

17

5 m V/div 1 m sec/div



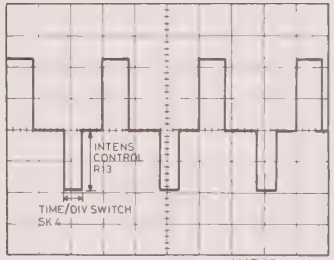
MAT 457

– D.T.B. TIME/DIV switch to 50μ sec/div
– push-button STARTS (D.T.B.) depressed

UNIT 8

17

5 mV/div 1 m sec/div



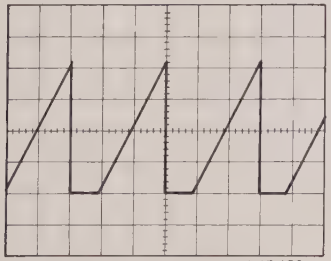
MAT 458

– D.T.B. TIME/DIV switch to 50μ sec/div
– D.T.B. LEVEL potentiometer to its mid-position
– push-button TRIG. (D.T.B.) depressed

UNIT 8

18

2 V/div 1 m sec/div



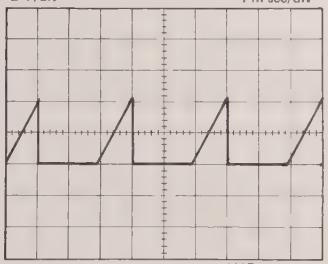
MAT 459

– X POSITION control in its mid-range

UNIT 8

18

2 V/div 1 m sec/div



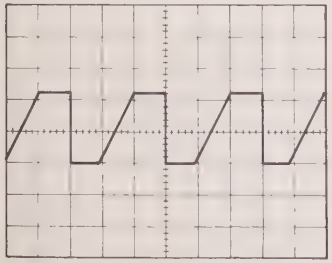
MAT 460

– X POSITION control fully counter clockwise

UNIT 8

16

0,1 V/div 1 m sec/div



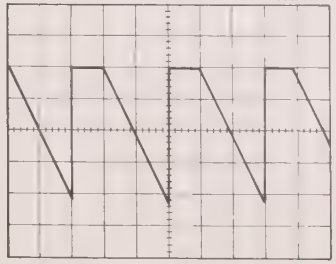
MAT 461

– X POSITION control fully clockwise

UNIT 8

19

2 V/div 1 m sec/div



MAT 462

– X POSITION control in its mid-range

CODING SYSTEM OF FAILURE REPORTING FOR QUALITY ASSESSMENT OF T & M INSTRUMENTS

(excl. potentiometric recorders)

The information contents of the coded failure description is necessary for our computerized processing of quality data.

Since the reporting of repair and maintenance routines must be complete and exact, we give you an example of a correctly filled-out PHILIPS SERVICE Job sheet.

① Country	② Day Month Year	③ Typenumber /Version	④ Factory/Serial no.
32	150475	OPM 3260 02	DO 0078 3

CODED FAILURE DESCRIPTION ⑥

⑤ Nature of call	Location	Component/sequence no.	Category
☐ Installation		TS0607	5
☐ Pre sale repair		R00631	2
☐ Preventive maintenance	0021	990001	4
☒ Corrective maintenance			
☐ Other			

⑦ *Job completed* ☒

Working time ⑧ 12 Hrs

Detailed description of the information to be entered in the various boxes:

①Country: 32 = Switzerland

②Day Month Year 150475 = 15 April 1975

③Type number/Version OPM3260 02 = Oscilloscope PM 3260, version 02 (in later oscilloscopes this number is placed in front of the serial no)

④Factory/Serial number DO0078 3 = DO 783 These data are mentioned on the type plate of the instrument

⑤ Nature of call: Enter a cross in the relevant box

⑥ Coded failure description

Location

☐☐☐☐

These four boxes are used to isolate the problem area. Write the code of the part in which the fault occurs, e.g. unit no or mechanical item no of this part (refer to 'PARTS LISTS' in the manual).

Example: 0001 for Unit 1
000A for Unit A
0075 for item 75

If units are not numbered, do not fill in the four boxes; see Example Job sheet.

Component/sequence no.

☐☐☐☐☐☐

These six boxes are intended to pinpoint the faulty component.

A. Enter the component designation as used in the circuit diagram. If the designation is alfa-numeric,the letters must be written (starting from the left) in the two left-hand boxes and the figures must be written (in such a way that the last digit occupies the right-most box) in the four right-hand boxes.

B. Parts not identified in the circuit diagram:

990000 Unknown/Not applicable
990001 Cabinet or rack (text plate, emblem, grip, rail, graticule, etc.)
990002 Knob (incl. dial knob, cap, etc.)
990003 Probe (only if attached to instrument)
990004 Leads and associated plugs
990005 Holder (valve,transistor, fuse, board, etc.)
990006 Complete unit (p.w. board, h.t. unit, etc.)
990007 Accessory (only those without type number)
990008 Documentation (manual, supplement, etc.)
990009 Foreign object
990099 Miscellaneous

Category

☐

0 Unknown, not applicable (fault not present, intermittent or disappeared)
1 Software error
2 Readjustment
3 Electrical repair (wiring, solder joint, etc.)
4 Mechanical repair (polishing, filing, remachining, etc.)
5 Replacement (of transistor, resistor, etc.)
6 Cleaning and/or lubrication
7 Operator error
8 Missing items (on pre-sale test)
9 Environmental requirements are not met

⑦ Job completed: Enter a cross when the job has been completed.

⑧ Working time: Enter the total number of working hours spent in connection with the job (excluding travelling, waiting time, etc.), using the last box for tenths of hours.

12 = 1,2 working hours (1 h 12 min.)

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